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ENCEPHALOGRAPHY AS THE ROENTGENOLOGIST SHOULD UNDERSTAND IT

AN ATTEMPT TO STANDARDIZE THE PROCEDURE[1]

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ENCEPHALOGRAPHY has become established as a valuable and reliable roentgenological procedure for the more exact diagnosis and localization in cases presenting symptoms of organic cerebral pathology which are more or less obscure. Roentgenologists are by this time fully cognizant of the difference between the procedures of encephalography and ventriculography. By means of the former we are now able to detect many cortical lesions that never could be diagnosed before the procedure was instituted, and varying in degree from their very incipiency to the most aggravated forms.

It is now possible by proper technic to obtain a clear visualization of the cerebral surfaces surrounded by cerebrospinal fluid. The outline of the fluid spaces when filled with air, as shown on the roentgenogram, is such that one familiar with the structures and neuro-anatomy can determine even slight disturbance in the relationships existing in various areas of the brain. By comparing the abnormal appearances of the fluid spaces with pathological specimens showing similar gross defects, or from verified operative findings following encephalography, it is now possible to interpret and diagnose correctly the major portion of these cases from a study of the roentgenograms, after due consideration of the history and neurological findings.

All accurate roentgenological diagnosis must be based upon a thorough knowledge of the anatomy of the part examined, a comprehensive understanding of the pathological changes in the conditions amenable to diagnosis, familiarity with normal radiographic appearances, and experience in interpretation.

Encephalography deals with a comparatively new field for the roentgenologist. His knowledge of brain anatomy has been largely forgotten. He is unfamiliar with cerebral neuropathology. As a result of these temporary shortcomings he cannot cooperate with the neurologist or neurological surgeon in the same way that he does in the elaboration of the most accurate diagnosis of conditions involving other parts of the body, as the chest and abdomen. Hence accurate encephalography has not been making the rapid strides it should have made. The roentgenologist in very many instances has been relegated to the position of a techni-

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cian, without the proper guiding mind and hand to direct him along such lines as to develop the best technic. As a result there is dom of exact standardization, especially when they are the ones most vitally interested in the need of precision and accuracy.

Fig. 1. Encephalographic chair devised for this procedure in place beside the vertical Bucky with fixed tube stand, preparatory to encephalography.

at present—or has been until quite lately—a total lack of standardization of the roentgenological technic in encephalography. It seems strange that many neurologists and neurological surgeons do not realize the wis- These requirements must be based upon the intensive interest of the roentgenologist, and surely technical work has very little interest for him. The highest development of this part of roentgenological diagnosis will be at-

tained only after his interest is fully aroused. It is only by a mutual understanding between us as roentgenologists and neurologists or neurosurgeons that any degree of perfection has been reached in obtaining perfectly satisfactory roentgenograms capable of proper interpretations. The mutual understanding of each other's problems has been productive of the best results.

As an example of the lack of co-operation, during a recent visit to a large and well known institution we were told by a neurological surgeon that he always made his own interpretations and that he did not believe this to be within the province of the roentgenologist. We were then asked to interpret some supposed encephalograms. Noticing some unusual peculiarities in their appearance we inquired as to how they were made and were rather startled to learn that the exposures were all being made with the patient in the horizontal position. These were, of course, not encephalograms at all, and represented the most flagrant violations of technic, and yet a neurological surgeon was attempting to make absolutely impossible interpretations from them.

Standardization of technic is of the utmost importance—this applies to both the surgical and the roentgenological procedures. Each should be carried out in a careful and exact manner in all essential details and should be capable of exact duplication in all cases. There are three important reasons for this: (1) All neurological surgeons and roentgenologists should be able to talk in the same language and be able to make interpretations of the roentgenograms of another group when supplied with the necessary clinical data; (2) it should be possible to make comparisons of the various stages of a progressive lesion at different periods; (3) in examining a group of individuals with the same or similar lesions, it should be possible to compare one with the other or to compile accurate data or collect valuable information. For these reasons we are making a plea for the standardization of technic among roentgenologists, and we are also offering them suggestions for the furtherance of a better understanding of the whole procedure of encephalography, to enable them to make correct interpretations.

(A) ROENTGENOLOGICAL TECHNIC

The essential features of the technic are technically perfect roentgenograms, just as in the chest or elsewhere in the body, and made in the vertical position. No conscientious roentgenologist will attempt to base a diagnosis upon mediocre or faulty roentgenograms of the chest. Technically perfect roentgenograms imply a correct technic on the part of both the roentgenologist and the neurological surgeon or neurologist making the air injection. Sufficient air must be admitted and properly distributed to enable any one to make correct interpretations. Insufficient air or failure to manipulate the patient for its proper distribution cannot do otherwise than lead to faulty interpretations. For example, in the absence of obstruction in the ventricular system, all of the ventricles should contain air. Failure of the ventricles to fill must be regarded as implying faulty operative technic unless it can be satisfactorily proven that some good reason exists for the exclusion of air or the emptying of fluid from the system. The same remarks apply to the filling of one lateral ventricle without midline shift.

Proper roentgenological technic should produce clear roentgenograms of the best possible detail in order to show the finer cortical air markings clearly, by contrast with surrounding brain structures. The first essential feature in the production of such roentgenograms is the use of the Bucky diaphragm. Encephalograms made without the use of this device will not answer our purposes. Various devices may be used so long as they embody the correct principles. The apparatus we have been using for the

past two or three years has been described by Pendergrass (25) 1927, (26) 1928, and by us (24) 1929. It has proved very satisfactory and is as safe as it can be made. A specially made reversible flat Bucky, originally intended for ventriculography, is suspended on an old stereoscopic chest shift, and can, therefore, be placed at any height to suit the patient. On the front are drawn two lines crossing the center at right-angles for purposes of properly placing the patient's head.

Fig. 2. The position of the patient for anteroposterior view with the Bucky tilted forward, the head of the patient fixed, plate changer and the body in position for this exposure. Note that the height of the chair permits change of position of the patient without disturbing the height of the Bucky diaphragm. The Bucky magnetic shift is operated from the transformer control.

The patient is brought into the examining room sitting up in a chair especially made

for this purpose, and in which the surgical part of the procedure has been performed (Fig. 1). This chair is simple in construction but should meet the following requirements: (1) Easy access to the spinal canal with the patient in the sitting position; (2) support for the patient so that the sitting position is maintained at all times during the air injection and throughout the transportation to the roentgenological laboratory as well as during the period of making the exposures; (3) rapid mobility of the chair by means of large castors so that ease of transportation as well as rapid changes of posi-

Fig. 3. Position of the head for lateral stereoscopic roentgenograms in encephalography. The patient must be maintained in the erect position throughout the entire examination.

tion during the roentgenological procedure may be accomplished.

As the initial pressure of the cerebrospinal fluid is always taken with the patient in the horizontal position before undertaking the air injection, the patient is transferred to the chair and placed in the upright position after this determination has been made. The air injection is always made in the sitting position.

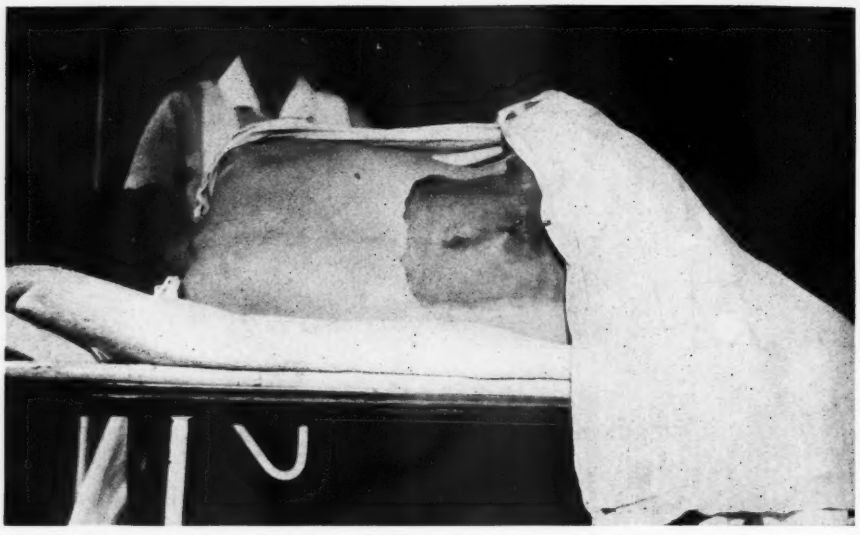


Fig. 4. Patient in horizontal position, preparatory to encephalography. Note two spinal needles in place. Initial pressure reading is always made in this position.

Although we have found such a chair a distinct convenience, in its absence the use of a litter will permit both the horizontal and sitting positions, the patient being transferred to a wheel chair and then again to the roentgenologist's stool. Movements of the patient necessary after each exposure being awkward under these conditions, the chair devised for this procedure has greatly simplified the handling of such cases. The use of such a chair implies that the distance between the tube stand and Bucky support must be ample to accommodate the chair and permit of its being turned around for the various views necessary. As encephalographic procedures are uncertain as to time, but the roentgenographic part of the work must be carried out as soon as the patient is brought to us, it behooves us to have our roentgenological equipment always in readiness, otherwise valuable time will be lost and the usual routine schedule of the department very much disturbed. For these reasons all that we have to do is to wheel the patient in front of our regular chest shift and suspend the Bucky upon it. The tube stand and tube are always in position for chest roentgenography at a target film distance of 48 inches: the suspended Bucky has brought this distance down to 44 inches (Fig. 1). This distance has the further advantages of eliminating distortions and adding to the clearness of detail.

Recently, because of the installation of a new chest shift, we have moved the old one and a tube stand into a separate small room where it is operated by its own transformer unit, the same target film distance being maintained. This obviates still further the necessity of disturbing the regular routine

work. Naturally the equipment for all of the roentgenographic procedure should be easily accessible to the room in which the

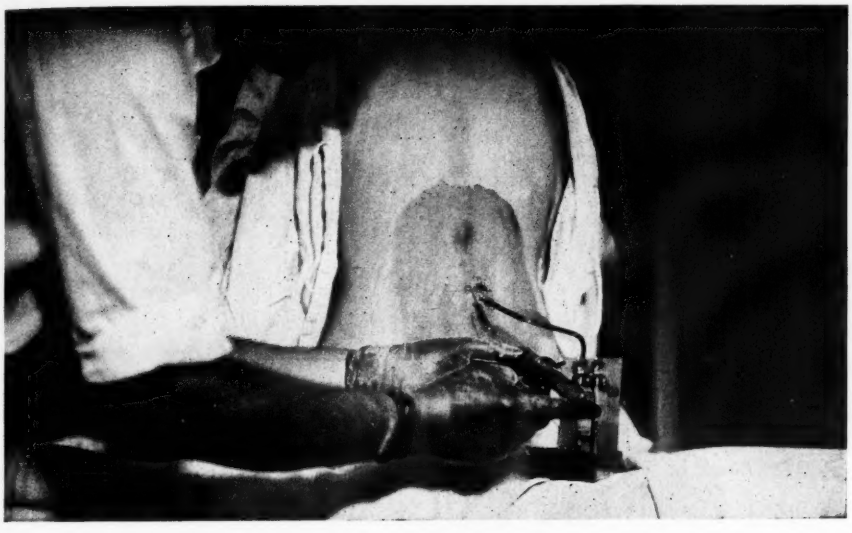
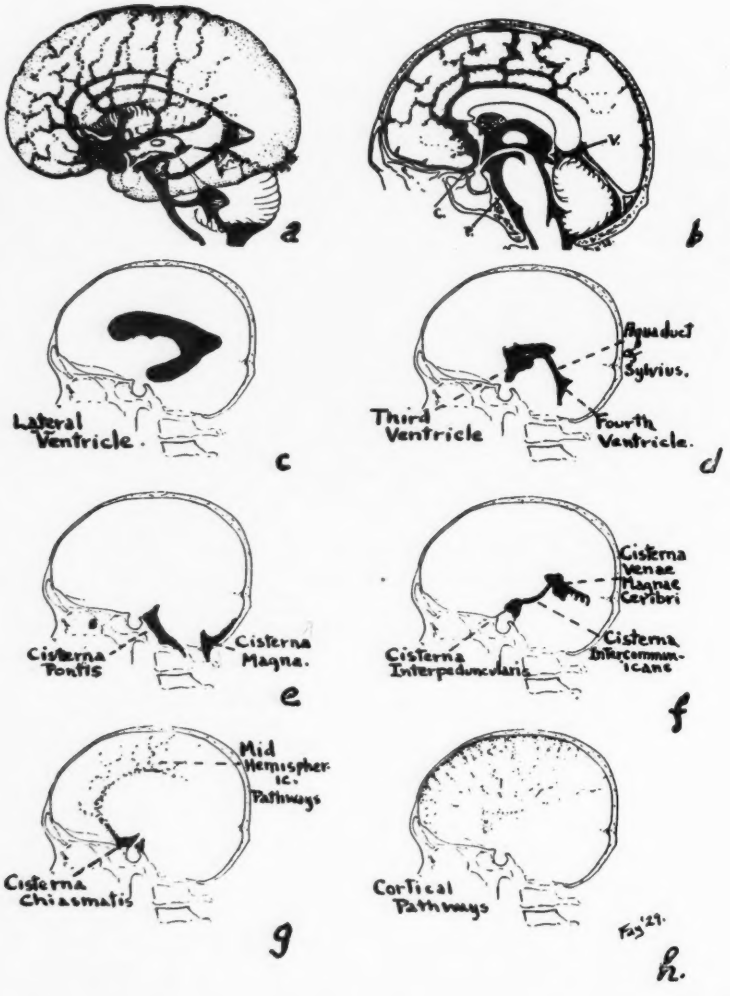


Fig. 5. Patient in the sitting position, with upper needle connected to a manometer and lower needle used for drainage of spinal fluid and the introduction of air. Care is taken never to permit intracranial pressure to rise above 20 mm. Hg.

operative technic is carried out. One man and nurse are trained to do all of the roentgenographic work and they can handle patients easily and also without disturbing the regular schedule. When the patient arrives he is wheeled on the chair in front of the suspended Bucky into position for the first or postero-anterior view. There is plenty of clearance for his legs and all parts of the chair under the cassette shift. His head is so placed that the midline of the forehead is in contact with the central line drawn on the Bucky. A long pointer from the tube holder, pointing at the midline of the back of the head, can be used to fix the head in an exact sagittal plane, but this becomes unnecessary with practice. A muslin restraining band is now applied to hold the head in this position, great care being required in placing the patient's head because it is absolutely essential that the central ray shall pass accurately through the mid-sagittal plane of the head in order, later, to be able to determine whether or not there is any midline shift of the brain structure, ventricles, or hemispheres. The head must be tilted forward in order that the lateral and third ventricles may be projected well above the frontal sinuses. This view gives clear definition to the anterior horns, third ventricle, and cortical air markings, especially those over the frontal lobes. The exposure factors we have found necessary for this view at 44 inches distance are 240 milliampere-seconds, with a six- to seven-inch spark gap. If stereoscopic films are desired, the tube shift must be five inches at this distance, and the shift should be vertical in order that flat film readings may be made from either roentgenogram. We have not found stereoscopy routinely necessary in this view. When stereoscopic exposures are made it is necessary with our equipment to change the cassettes by hand instead of by an automatic shift.

The patient's head is then released and the chair turned around for the posterior view,

to show especially the posterior horns of the lateral ventricles, and also the cortical air markings. The same care is required in placing the head correctly as for the anterior view. It is well fixed and the restraining band is placed over the chin to hold it so, in order, again, that the lateral and third ventricles may be projected clear of the upper accessory nasal sinuses (Fig. 2). The exposure factors are the same as for the anterior view, although stereoscopic roentgenograms are here important.



Figs. 6-*A* to 6-*H*. Diagrammatic representations of the cerebrospinal fluid pathways and spaces, showing sagittal sections with a key to the principal cisternæ usually visualized on the roentgenogram. Obstruction to the passage of fluid along any of these pathways produces dilatation behind the point of obstruction and failure to fill the distal channels.

The patient and chair are next turned laterally for the side views. The central sagit-

tal plane of the head must be exactly parallel to the Bucky and the position must be midway between flexion and extension. The exposures are always essential in this direction. The shift is 5 inches at the 44-inch distance, and should be lateral, in order that

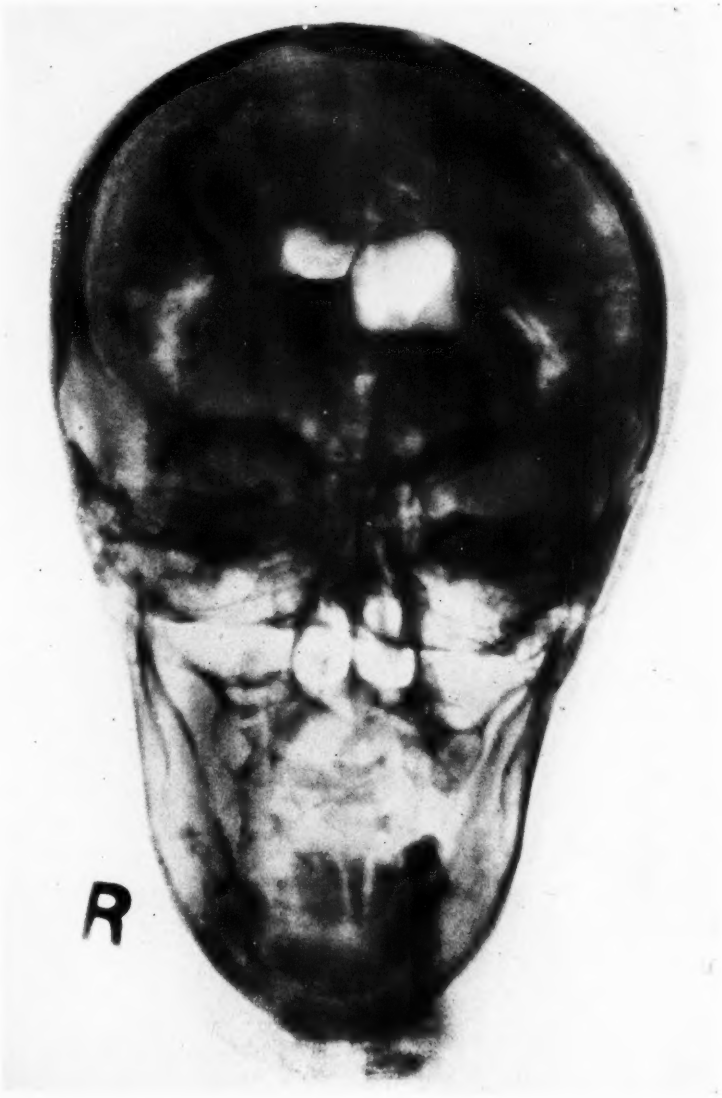


Fig. 7. Anteroposterior view of an epileptic with marked mental deficiency, showing bilateral atrophy in the Island of Reil areas, poor filling of the cortical air spaces, and only partial drainage of the right ventricle.

shoulder will just clear the under edge of the Bucky. The restraining band is again used to fix the head (Fig. 3). Stereoscopic the basal cisternæ and ventricles will not seem distorted in their relation with the skull base in looking at a single roentgeno-

gram, or, more especially, its reproduction in a slide or print. The exposure factors for this view are 120 milliampere-seconds each, with a 6- to 7-inch gap. Similar lateral stereoscopic views are then made of the other side of the head. In these, it is well to place the lead side marker just below the level of the patient's ear, where its shadow will always be seen and it will not be in the way of any important structures. It is always well to have the upper cervical spine show on the lateral roentgenograms, for occasionally there may be a block in the region near or at the foramen magnum and it should be detected. This precaution was on one occasion the means of making a very important diagnosis in an obscure case that had been thoroughly studied and not detected by a number of other individuals. It was found that air failed to reach the cranial cavity and thus disclosed an obstruction due to an occipito-atloid dislocation.

General anesthesia is always conducive to failure in accurate and satisfactory encephalograms, and it should be avoided always unless it is absolutely necessary. The patient will not stop breathing and the proper manipulation and fixation of the head are extremely difficult. We have found it rarely necessary in adults, although it cannot be avoided very often in young children and infants.

The technic in children requires much less exposure. A higher milliamperage is required, and usually at the expense of the penetration factor for the sake of safety to the tube. In young children at the 44-inch distance we are employing the 100 milliampere Coolidge tube at 100 milliamperes and a 5-inch gap. With these factors, the sagittal exposures require three seconds and the lateral ones two seconds. A higher milliamperage may be used if more speed is required, but the voltage cannot, of course, be raised. Adequate exposure is the second requisite for satisfactory roentgenograms, and under-exposed ones are not only unsatisfactory but they may be misleading.

The third requisite for accurate work is that the encephalograms must be made within one hour after the air injection, as otherwise unnatural appearances are likely to be encountered. Also, the patient must not be permitted to assume the horizontal position until all of the exposures are made. With the proper equipment and a well trained group of workers, the entire roentgenographic procedure for the seven necessary exposures should not require over ten to twelve minutes from the time the patient is brought into the examining room.

Because of the vertical position of the patient, fluid cannot be drained from the descending or inferior horns of the lateral ventricles, and as a result no air enters these dependent portions of the ventricular system. Sometimes it is necessary to see them because of possible displacements, deformities, or obliteration. After the usual encephalograms are made in the erect posture it is quite easy to place the patient on the horizontal ventriculogram table and make lateral views, which will then show these missing portions of the cavities.

Some neurosurgeons prefer to admit the air by cisternal puncture into the cisterna magna. Roentgenograms made after this procedure are not as satisfactory because the air filling is never as complete as after the usual lumbar method of introduction. The reason for this is that the head cannot be so well manipulated for the drainage of fluid and the admission of air to all parts of the fluid pathways because free movements are restricted by the presence of the needle at a point of disadvantage. Cisternal punctures are occasionally necessary, but they should be avoided as routine procedures.

It will be noted from the foregoing description of an exact roentgenographic technic, that it, as well as a correct interpretation, depends to a very great extent upon the

surgical part of the procedure. The roentgenologist should be competent to take a stand that the latter must be carried out in a correct and advantageous manner, and his word should have due weight, just as in other combinations of minor surgical and roentgenographic procedures.

(B) THE PREPARATION OF THE PATIENT FOR ENCEPHALOGRAPHY (SURGICAL TECHNIC)

The indications for encephalography must be clear-cut in selecting the patient for this procedure. The slight risk and intense headache attendant upon the examination should militate against its use as a short-cut

Fig. 8. Normal anteroposterior view, showing convolutional markings without distortion or enlargement. The third ventricle, aqueduct, and fourth ventricle are usually seen.

to diagnosis. The case must have been carefully studied neurologically before attempting an encephalographic study. As

Fig. 9. Lateral view of the normal, showing hairpin-like markings and filling of the entire cerebral cavity by brain structure. Ventricles are normal. It is possible in this case to visualize the vermis in the cerebellum; fourth ventricle and aqueduct are clearly seen and cisterna venæ magnæ and cisterna chiasmatis appear slightly enlarged. Patient suffered from middle ear disease without intracranial complications. The absence of intracranial symptoms for the past nine months, as well as the negative neurological examination, taken with the encephalographic findings, leads us to believe this is a normal figure.

there are definite contra-indications to this procedure, these must be ruled out before undertaking encephalography. In suitable types of cases, it is a method of great value, and when properly performed has practically no risk or serious consequences. The resultant headache disappears in from three to five days, the patients promptly returning to their former degree of comfort and activity.

The visualization of the cerebrospinal fluid spaces and pathways within the skull requires the complete drainage of cerebrospinal fluid from the cranial cavity, and its replacement by air. This must be done with due regard to pressure relationships, and a constant reading of intracranial pressure by a manometer (mercury or water) must be maintained throughout the exchange of fluid and air.

It is at once evident that if a patient has a tumor mass in the posterior fossa, or ob-

struction to the outlet of fluid from the ventricles such as is present in internal hydrocephalus, cerebrospinal fluid cannot be properly drained from the cranial cavity or air introduced, and encephalography in this type of case is unsatisfactory and contra-indi-

Fig. 10. Right hemisphere of the brain showing the normal situation of Pacchionian granulations near the midline; their attachment to the dura, and the enlargement of fluid pathways in the sulci anterior to the area of thickening arachnoid seen from the motor cortex. Case of idiopathic epilepsy. (Preparation by Dr. N. W. Winkelman.)

Fig. 11. Compensatory pathways radiating from the cisterna venæ magnæ cerebri, which is greatly enlarged. Note the failure to fill any of the normal pathways over the frontal or parietal areas. The cisterna chiasmatis and pontis are not filled, although the ventricles and cisterna venæ magnæ show no obstruction. This case proved to have an obstructive arachnoiditis in the cerebellopontile angle, thus preventing air from reaching the cortex in the usual way, a compensatory mechanism to the vertex being established.

cated. Far more important is the danger such cases present, because they usually are attended by increased intracranial pressure and the withdrawal of spinal fluid may allow the brain to expand in the direction of the release of pressure so as to force the cerebellar hemispheres into the foramen magnum, producing a hernia with pressure on the medulla, and respiratory failure. This is a real danger and has led to the adoption of an arbitrary level of pressure above which we believe encephalography is unsafe.

It is our opinion that encephalography is contra-indicated when spinal fluid pressure is above 20 mm. Hg, with the patient in the horizontal position and resting quietly. Pressures above 20 mm. Hg are usually associated with some profound obstruction to the cerebrospinal fluid circulation and require careful consideration to rule out a posterior fossa lesion or obstruction in the outlets to the ventricles, making encephalography dangerous, as well as unsatisfactory.

When a careful history and neurological examination have shown the patient to be suffering from cerebral symptoms, and lumbar puncture indicates spinal fluid pressure below 20 mm. Hg in the horizontal position, encephalography may be indicated and safely performed.

We have found the safest and easiest

method of air injection to be the following: The patient is placed on a litter in the horizontal position, with knees drawn up preparatory to a lumbar puncture. The skin in the lower lumbar region is carefully prepared with alcohol and iodin. The operator should wear sterile gloves and maintain careful aseptic technic throughout. Novocain is introduced in the skin over the fourth and fifth lumbar interspaces, respectively. A lumbar puncture is then done, using an eighteen gauge "Green" round-point, or "Babcock" nickeloid steel needle. The spinal manometer is connected to the needle, and the initial pressure reading made. The normal pressure in this position should be about 8 mm. Hg. If the pressure is above this level, such as 14 or 16 mm. Hg, spinal fluid is allowed to drain from the needle until the pressure has fallen to 8 mm. Hg (Fig. 4).

If the pressure reading is 20 mm. Hg or over in this position, the encephalogram is contra-indicated, unless the operator deliberately assumes the added risk where localization or confirmation of a lesion is imperative. It is better, provided encephalography is desirable, to actively dehydrate the patient for several days and again make a pressure reading, as frequently reduction of intracranial pressure resulting from dehydration makes possible a safer level of pressure to carry out the procedure. With the finding of the pressure below 20 mm. Hg, a second spinal needle is introduced one interspace higher, the manometer disconnected, and the stilets of the needle replaced. With two needles in place, the patient is then carefully raised to the sitting position or transferred to the encephalogram chair, with the head in the midline and flexed slightly forward (Fig. 5).

The manometer is now connected again with the upper needle and should register in the normal adult about 20 mm. Hg. The change of pressure from 8 mm. Hg in the horizontal position to 20 mm. Hg in the sitting position is due chiefly to the height of the spinal canal, and the added weight of the column of fluid in the upright position. Patients with short backs often show 16 to 18 mm. Hg of pressure, whereas, those with longer spinal canals may register 26 to 28 mm. Hg, the average normal pressure in the sitting position being about 20 mm. Hg. It is evident that should the patient have increased intracranial pressure in the horizontal position, such as 18 mm. Hg, and then be raised to the sitting position, the pressure may reach 40 mm. Hg, a level felt to be too high for safety. It is for this reason that fluid pressure when over 8 mm. Hg in the horizontal position, is allowed to fall to 8 mm. Hg before placing the patient in the sitting position preparatory to continuing the spinal drainage.

With the patient in the sitting position and the manometer connected to the upper needle, the stilet is withdrawn from the lower needle and spinal fluid allowed to drop from the needle until the pressure has fallen from around 20 mm. Hg to 10 mm. Hg. This usually occurs when from 15 to 30 c.c. of spinal fluid has escaped. With a sterile 20 c.c. syringe, air is now introduced into the lower needle, watching the pressure on the manometer until it has been raised again to 20 mm. Hg. This may require 5, 10, or 15 c.c. of air, but it is important not to try to replace air in equal amounts for fluid obtained. The pressure readings indicate the safest amount that can be replaced at each interval so as not to produce an increase in intracranial pressure. Room air expands when raised to body temperature, and thus the "volume for volume" method produces increased intracranial pressure and disturbing symptoms in the patient. The "pressure for pressure" method maintains the patient in a constant regulated equilibrium, and has not been associated with any untoward symptoms in our experience (Fig. 5).

With the introduction of the air and the rise of pressure to 20 mm. Hg, drainage from the lower needle is again permitted un-

til the pressure falls to 10 mm. Hg, when 10, 15, or 20 c.c. of air is introduced, depending upon the amount required to raise the pressure again to 20 mm. Hg. This procedure is repeated until the entire amount of

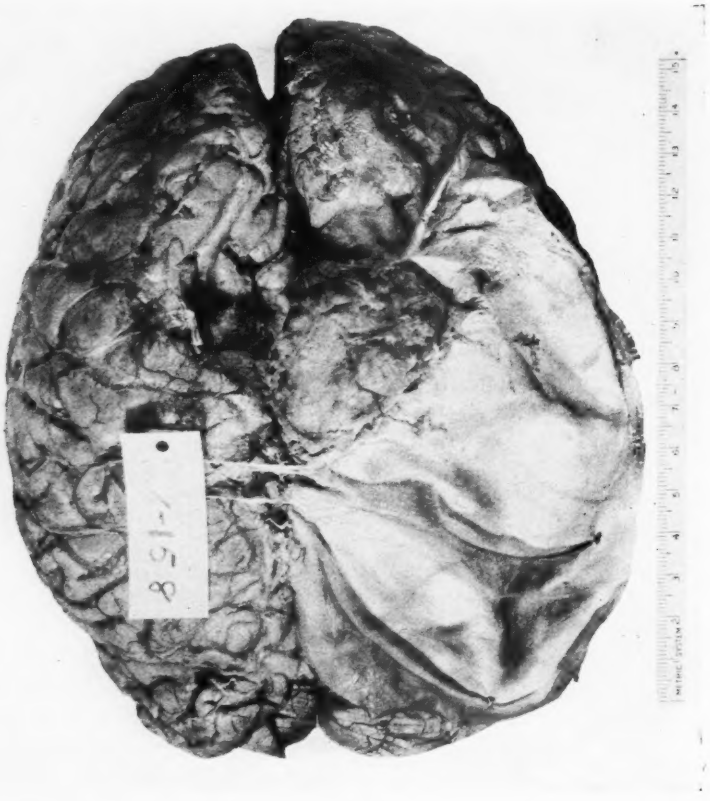


Fig. 12. Large midline endothelioma, showing pressure atrophy of the brain and enlargement of fluid spaces in the region of the tumor. Cortical pathways are obliterated on the lateral surface of the brain due to flattening of the convolutions. Fluid pathways in the frontal lobe show enlargement with pressure atrophy behind the point of obstruction by the tumor. (Preparation by Dr. N. W. Winkelman.)

cerebrospinal fluid that can be obtained has been replaced by air, the point being indicated by the return of bubbles from the needle. *At least 100 c.c. of air* should be used to insure a satisfactory encephalogram.

During the period of drainage and replacement of spinal fluid by air, the patient's head is carefully rotated, flexed, and extended. The chin is depressed to the chest, and then slowly elevated so that the head is extended. Rotation of the head is carried toward the shoulder and back to the midline, first to one side and then to the other. The head is always returned to the midline before beginning a new series of movements. The regular movements of the head should be carried on during the drainage and should include ten or more repetitions of each movement. Jarring the head slightly

with the open palm seems to assist in draining the smaller pathways, and this should be repeated three or four times. It is most important that the entire procedure be carried out in the sitting position and the head maintained in the midline, not only for the period of injection, but also during the time required to take the patient to the roentgenological department, and throughout the entire roentgenographic procedure. If the patient is allowed to lie down, or the head permitted to incline to one side, air will rise in the fluid spaces to the highest point and produce unequal distribution and misleading effects, which vitiate attempts at interpretation later.

Figs. 13 (*left*) and 14 (*right*). Anteroposterior and lateral views of case of endothelioma in the parietal lobe. Note displacement of the structure at the midline away from the tumor, with depression of the roof of the ventricles on the left, characteristic failure to fill cortical air spaces. Tumor removed at operation by Dr. Frazier.

The roentgenologist requires perfect and uniform technic by the operator in his introduction of the air so that proper interpretation of the roentgenograms can be made. Too much emphasis cannot be placed on the proper manipulation of the head during the injection period, and its maintenance in the midposition at all times subsequently, even though the patient may desire to lie down.

There are definite symptoms which accompany the period of air injection which may disturb the operator if he is not familiar with their occurrence. The patients complain of severe frontal headache early in the injection, sweating breaks out on the forehead and becomes generalized. They may feel faint and frequently vomit during the procedure. The pulse may become rapid, or slow down to sixty beats per minute. These symptoms are almost always present during the procedure and need not alarm the operator if careful manometric readings indicate that the intracranial pressure has not been increased above 20 mm. Hg at any time. Chloral hydrate given before and after the procedure assists in the control of headache and the comfort of the patient. The gradual replacement of fluid bv air gives the least reaction. *Fluid should never be sucked out of the spinal canal by the syringe.*

The patient is usually left with 10 mm. Hg of pressure at the termination of the air injection. It will be found frequently that there is 10 to 12 c.c. more fluid withdrawn

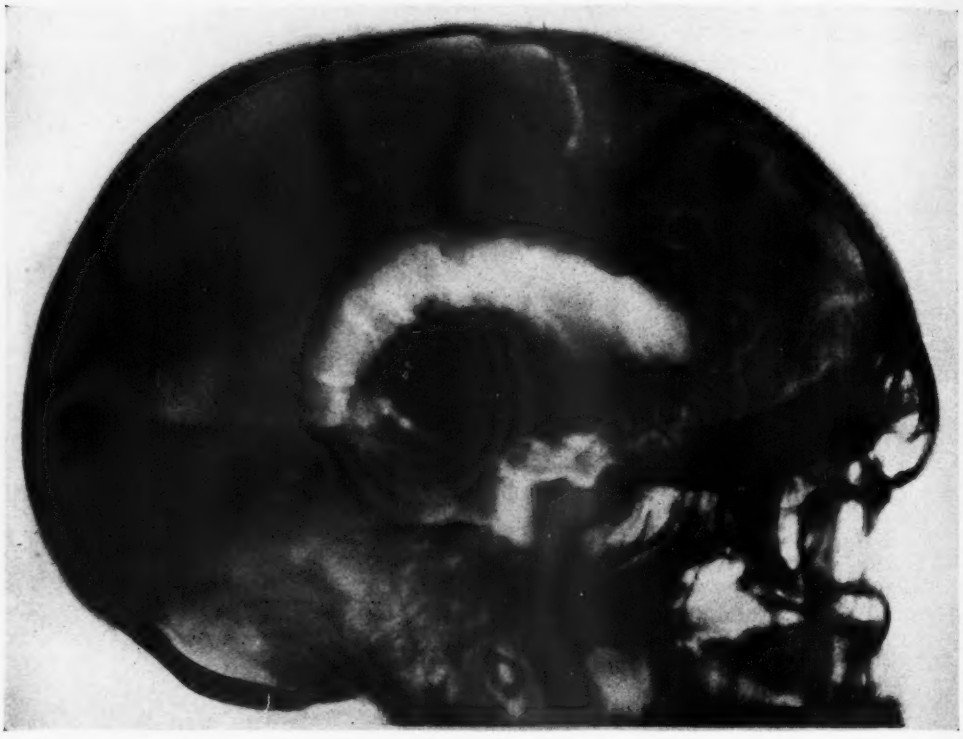


Fig. 15. Compensatory pathways over the frontal region passing through a field of arachnoiditis. Note evidence of chronic intracranial pressure by enlargement of cisterna chiasmatis pontis and the fourth ventricle and unilateral dilation of the lateral ventricle.

than air introduced, and this difference in volume may be accounted for by expansion of air and engorgement of the cerebral vessels. As long as the final pressure remains the same as the original pressure, a safe balance is maintained.

With the completion of the introduction of air, the spinal needles are withdrawn and the patient placed in a wheel chair and maintained in the upright position while being taken to the roentgenological department, or better, the surgical procedure should be carried out in the same chair as is used for the roentgenographic exposures (Fig. 1).

NEURO-ANATOMICAL RELATIONSHIPS

As the surfaces of the brain visualized by encephalograms are those surrounded by gross amounts of cerebrospinal fluid, it is important to have clearly in mind the characteristics of these spaces as found in what may be considered the normal. Tracing the course taken by cerebrospinal fluid in its circulation from its source within the ventricles to its points of absorption at the periphery, a clear understanding of the defects which may be produced by obstructive lesions can be gained.

It has become accepted that cerebrospinal fluid is elaborated for the most part through the choroid plexuses, situated in the lateral, third, and fourth ventricles of the brain. Fremont-Smith (13) has shown that it is a dialysate from the blood plasma, and similar to other tissue fluids (edema and ascites) in its protein content. He points out its

similarity in this respect to glomerular urine, analyzed by Wearn and Richards (36). The amount of this fluid produced each day may vary greatly. It is variously estimated at from 30 to 50 c.c., though it is known in cases of cerebrospinal fistula to be produced at the rate of 200 to 700 c.c. daily. The failure of this fluid to escape properly from the ventricles produces the well-known type of internal hydrocephalus. The lateral ventricles communicate with the third ventricle by merging toward the base of their anterior horns, leaving an opening, the foramen of Monro (Fig. 6-*A*). It is at once evident that if an obstruction occurs at the outlet of one ventricle, the accumulation of spinal fluid will produce a unilateral dilatation which will push the midline structures to the opposite side, encroaching upon the lumen of the other ventricle. At the same time pressure atrophy of the brain occurs and the enlargement of the ventricle takes place in all directions, as we have previously shown (24). When a unilateral dilatation of a ventricle is found by encephalogram, it at once indicates that the obstruction producing the dilatation no longer exists, as air could not have entered it otherwise. Such a finding would indicate a process which had occurred early in the history of the case, and finally reopened the outlet, after its dilatation had reached a point of overcoming the obstruction.

The failure of one ventricle to fill does not necessarily indicate a pathological obstruction, as this defect has been noted in cases where improper manipulation of the head had occurred, or some error in the technic of air injection existed (Fig. 7). The fluid emptying from both lateral ventricles into the third ventricle passes into the aqueduct of Sylvius on its way to the fourth ventricle (Fig. 6-*D*). It is in this narrow aqueduct that obstructions frequently occur, leading to an internal hydrocephalus, characterized by symmetrical dilatation of both lateral ventricles, and the third ventricle as well.

If the lateral ventricles fill with air, it is *prima-facie* evidence that there is no existing obstruction in the ventricular system. We cannot state dogmatically the exact normal size and shape of the lateral ventricles in the living subject nor the variations within normal limits (Figs. 8 and 9). There are many reasons for this. In the first place, encephalographic procedures have not been carried out upon many known normal subjects, and the best we can do is to collect a large number of encephalograms that are interpreted as negative and from these decide as best we can what a normal size and appearance would be. Secondly, there has been, up to the present time, little uniformity in roentgenological technic, and the procedure must become standardized. Thirdly, the operative technic must be similarly standardized. Naturally our interpretation as to the configuration and size of these ventricles must be based in all instances upon the two sagittal and the lateral views. The obliteration of the angle in the roof of the lateral ventricle at the juncture of the body and posterior horn as a sign of enlargement or dilatation, as once suggested by Dandy (6), does not hold good, as it will not disappear until great dilatation occurs. The foramina of Monro are usually perceptible normally and become progressively wider with dilatation.

The third ventricle configuration as shown in the lateral view corresponds closely to the text-book description. It enlarges in all directions, with its shape and irregularities fairly well preserved until it becomes quite large. The greatest enlargement seems to be downward and forward to the sella turcica. The aqueduct is always a rather narrow channel and, while it does widen under pressure, the increase does not keep pace with the widening of the foramina of Monro or the dilatation of the lateral

ventricles. Tumor masses arising in the third ventricle may obstruct the opening to the aqueduct and also produce an internal hydrocephalus. A filling defect of the third ventricle is usually apparent, however, and is thus distinguishable from a lesion within the aqueduct itself. Tumors of the fourth ventricle obstruct the outlet for spinal fluid at the lower end of the aqueduct, and thus produce a dilatation of the aqueduct, as well as the third and lateral ventricles.

Fig. 16. Distortion of the ventricles and displacement of the midline structures due to glioma in the right temporal lobe. Note dilation of the opposite ventricles. Absence of cortical air markings illustrates obliteration of fluid pathways over both hemispheres.

It is at once evident that lesions situated in this area sufficient to block the outlet of spinal fluid, also prevent air from entering the ventricles, and hence no filling of the ventricles is possible by the lumbar insufflation of air. In these cases, ventricular puncture by means of a trephine through the skull in the occipital region is the means by which such obstructions are shown. Air is introduced directly into the ventricles and the procedure is known as ventriculography. It is not only impossible to introduce air by the lumbar route into the ventricles when

an obstructive lesion is present in the third or fourth ventricles, but it offers a very distinct danger to the patient, and is considered the greatest contra-indication against encephalography.

The danger is a real one, due to the trapped fluid within the ventricles being under pressure. If spinal fluid be withdrawn from the lumbar sac in such a case, the fluid under pressure within the ventricles may force the tips of the cerebellar hemispheres into the foramen magnum, and produce a hernia. The pressure of such a herniation upon the medulla may produce a rapid re-

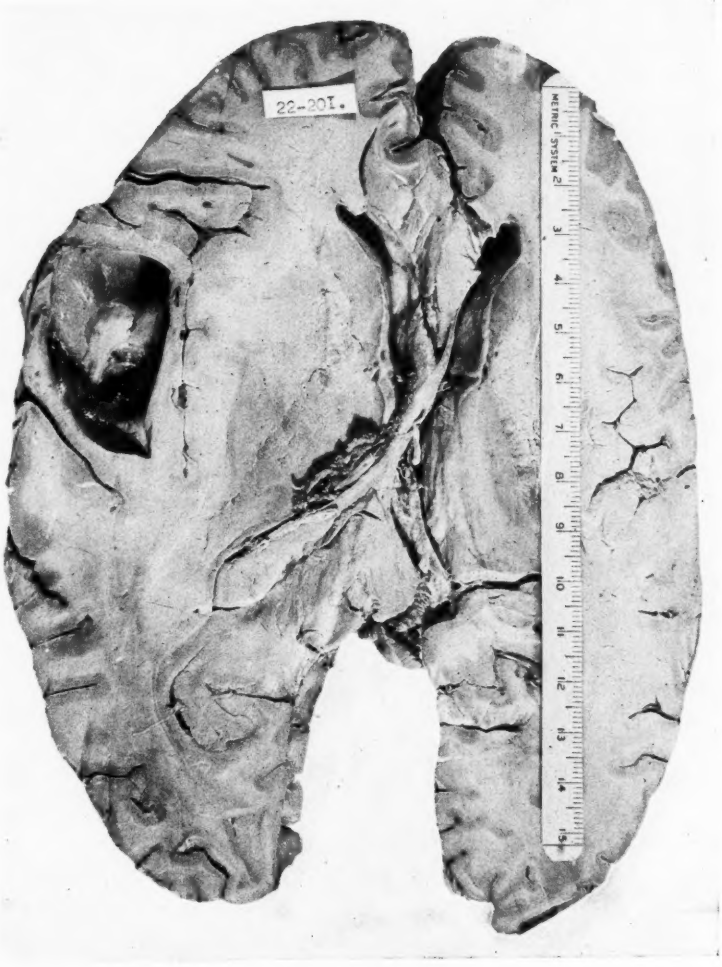


Fig. 17. Gliomatous brain, with cystic degeneration. Notice the filling defect of the ventricles, "ironing out" of the sulci, and flattening of the convolutions, not only on the side of the tumor but on the opposite side as well, due to increase in volume in brain and displacement beyond the midline. (Preparation by Dr. N. W. Winkelman.)

spiratory failure, and death. This has been found to be a frequent cause of death in brain tumors, either spontaneously or short-

Luschka and Magendie into the subarachnoid spaces about the medulla, in the region of the foramen magnum (Fig. 6-*A*). There

Fig. 18. Widespread arachnoiditis of the cortex in the presence of ventricular deformity. Evidence of brain destruction indicated in the large collection of air in the region of the Island of Reil on the side of the ventricular deformity. Post-traumatic epilepsy developed eight years after a fall of twenty-eight feet.

ly after lumbar puncture, and experience in this mechanism has led to the avoidance of such a circumstance when undertaking encephalography.

Cerebrospinal fluid escapes from the fourth ventricle through the foramina of

may be a membrane over the outlets of the foramina of Luschka and Magendie, shown by Bateman (2) as occurring in a small percentage of mental defectives. It is possible under such circumstances that fluid might pass through the membrane, but it would be

impossible to introduce air into the ventricles. Such an explanation for the occasional failure of the ventricles to fill when no increased pressure exists, or signs of posterior fossa lesion are present, may be offered in certain cases, but the majority of failures to fill the ventricles we believe to be an error in the technic of air injection. If the procedure is repeated and a similar result obtained, after careful rotation and manipulation of the head, the possibility of such a lesion may be considered. If possible, the patient should have a ventriculogram to establish the size and position of the ventricles before a positive diagnosis can be made. In several cases we have found that a roentgenogram taken twenty-four hours later showed air within the ventricles when no filling was seen at the time of the encephalography.

Occlusion of the aqueduct of Sylvius may occur from the overgrowth of neuroglia and, by its obstruction, simulate other forms of obstruction, as by tumor.

We wish to emphasize the fact that obstructive lesions situated between the third ventricle and the outlets from the fourth ventricle offer a distinct contra-indication to encephalography, not only because of the inability to obtain a satisfactory visualization of the ventricular outline, but also because these lesions are usually associated with increased intracranial pressure, due to an internal hydrocephalus, and may produce consequences dangerous to the patient because of a foramenal hernia, if spinal fluid is withdrawn.

There has been but one death in our series of 117 cases and this fatality occurred three days after encephalography. The patient had a huge right hemispheric glioma. The procedure was undertaken with full knowledge of the increased risk in such a case, as gliomas may produce rapidly fatal symptoms following even lumbar puncture. The futility of operation in this case was demonstrated by encephalography, and later verified at autopsy.

It is our opinion that the safety of the procedure lies in careful consideration of the neurological symptoms, and especial regard to the spinal pressure. If the pressure is found to be 20 mm. Hg or over, the likelihood of a severe form of obstruction contra-indicates the procedure until pressure may be reduced below this point by dehydration or the history and findings clearly rule out a posterior fossa lesion.

In tracing the spinal fluid after it leaves the foramina of Luschka and Magendie, we accept the views of Weed (30) that the major points of absorption for this fluid are the subarachnoid villi and Pacchionian bodies. The principal collection of these structures is at the vertex (Fig. 10). A small amount of spinal fluid escapes along the nerve roots of the spinal canal, as Weed has demonstrated. Recently Hassin (23) has shown arachnoid villi present about the spinal nerve roots, although he does not attach the value to them of filters for cerebrospinal fluid. A group of these villi are also found in the cisternæ venæ magnæ cerebri (Fig. 6-*F*). They are most numerous, however, on each side of the longitudinal sinus in the frontoparietal area of the brain.

Spinal fluid must, for the most part, find its way from the region of the posterior fossa where it first becomes subarachnoid, into the cisterna magna and pontis, thence through the incisura tentorii, to the cisterna chiasmatis, where it is distributed about the infundibulum and chiasm (Figs. 6-*A* and 6-*F*). It then finds its way along the Sylvian fissures on each side and between the frontal lobes of the brain in the midline (Fig. 6-*B*), thence by devious channels formed by the sulci between the convolutions of the brain to the vertex. The field of cortical circulation is confined to the surfaces (mesial and lateral) of the frontal lobes, and as far posteriorly as the Sylvian

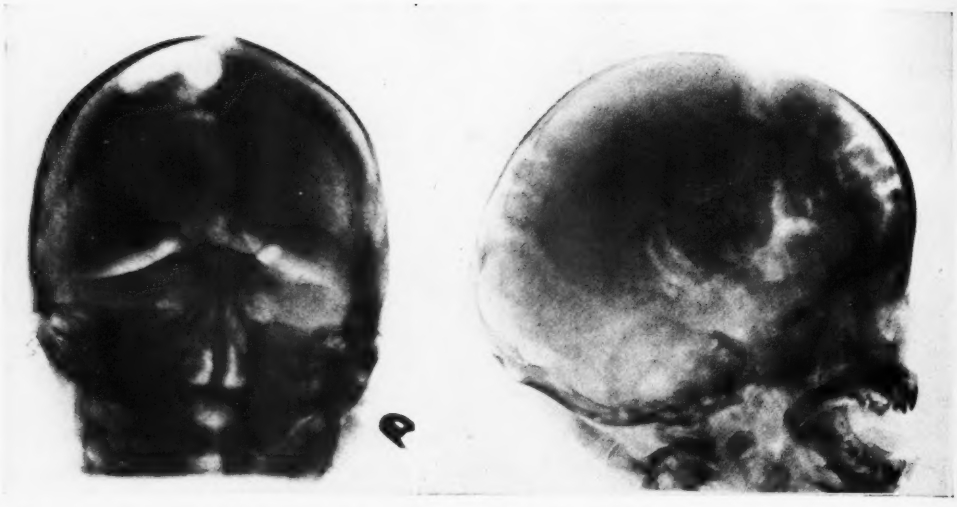


Fig. 19. Anteroposterior view of six-months-old infant showing spasticity and convulsive seizures following birth trauma. Note unilateral brain atrophy on one side and undrained area probably associated with arachnoiditis as well as atrophy on the other. Great enlargement of the cisterna venæ magnæ cerebri.

Fig. 20. Cortical atrophy seen in nine-months infant following birth trauma. Note the increased air in the region of the Island of Reil, with marked involvement of the frontal pole. No ventricular filling, probably due to insufficient air.

fissure and its juncture with a line drawn to the parieto-occipital sulcus (Figs. 6-*A* and 6-*H*).

It is important for the roentgenologist to be familiar with the approximate normal size or width of the cortical pathways as well as their normal distribution. As in the case of the lateral ventricles, we cannot determine measurements from known normal subjects, and must obtain an approximate idea of what should be normal from the study of a large number of negative cases in which no lesion could be demonstrated. This seems to be a reasonable deduction provided the general appearances in such cases are practically identical (Fig. 9). If one looks at a flat lateral roentgenogram of such a case, there are two general sizes of cortical pathways. One is narrow and corresponds to the size on the side examined, while the wider pathways correspond to those seen through from the opposite side. These can be differentiated in the stereoscope, but one cannot measure such narrow spaces stereoscopically with accuracy. In the past, we have been accustomed to describe the supposedly normal cortical pathway as of hairpin size. Recently, the Encephalogram Committee appointed by the American Roentgen Ray Society (12) determined the width of the normal pathway on the side being examined as approximately 1 mm. and the projected pathways from the opposite side and seen through as approximately 3 millimeters. Midline pathways are readily distinguished from those over the cortex by the fact that they arise from a sagittal channel above the level of the corpus callosum (Fig. 6-*B*), whereas the lateral cortical pathways arise lower down (Fig. 6-*A*).

In its subarachnoid course from the posterior fossa forward spinal fluid must pass through the narrow channels on each side of the pons caused by the incisura. It is at this point that relatively small tumor masses,

such as acoustic tumors or cerebellopontile angle tumors, may effectually block one side and displace the structures, so that they obstruct the opposite pathway. In this type of case when the stage of obstruction is reached, pressure rises rapidly, and choked discs, with headache and vomiting, indicate the signs of intracranial pressure.

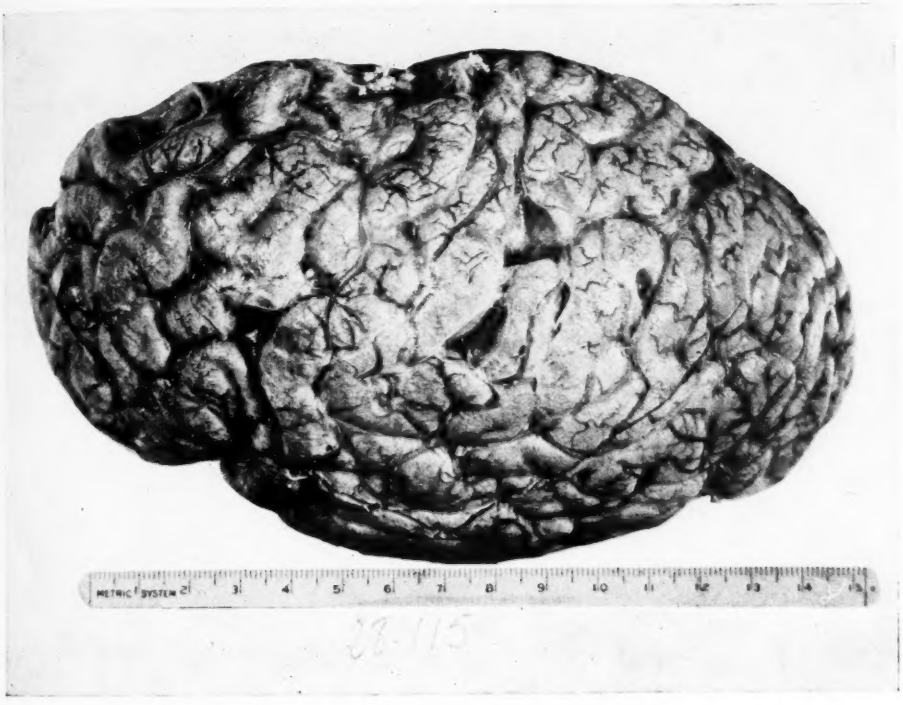


Fig. 21. Cystic areas of fluid and resultant pressure atrophy in a case of idiopathic epilepsy. Note the scarcity of normal Pacchionian bodies, the enlargement of the fluid pathways over the frontal and parietal areas, and the complete escape from this process in the temporal occipital regions of the brain. (Preparation by Dr. N. W. Winkelman.)

Because of the high pressure and the possibility that the tumor may press sufficiently against the pons to close the aqueduct of Sylvius, encephalography has been considered as contra-indicated, or certainly attended by more risk than usual in this type of case. However, the procedure in our hands has shown clearly the point of obstruction in several cases. Fluid accumulations greater than normal are seen about the posterior fossa by the air injection method in such cases. The cisternæ pontis and magna are enlarged. Air does not show in the cisterna chiasmatis region, or over the cortex, thus demonstrating the block to be at the level of the incisura (Fig. 11). Occasionally the ventricles do not fill, due to closure of the aqueduct by pressure. The findings are similar to those in cases in which obstruction exists just above the incisura on the chiasmal side. It will be noted that the structures at the base are well shown for the posterior fossa, but no air is seen above the tentorium or in the ventricles.

In the consideration of the lesions above the tentorium we enter the field of greatest

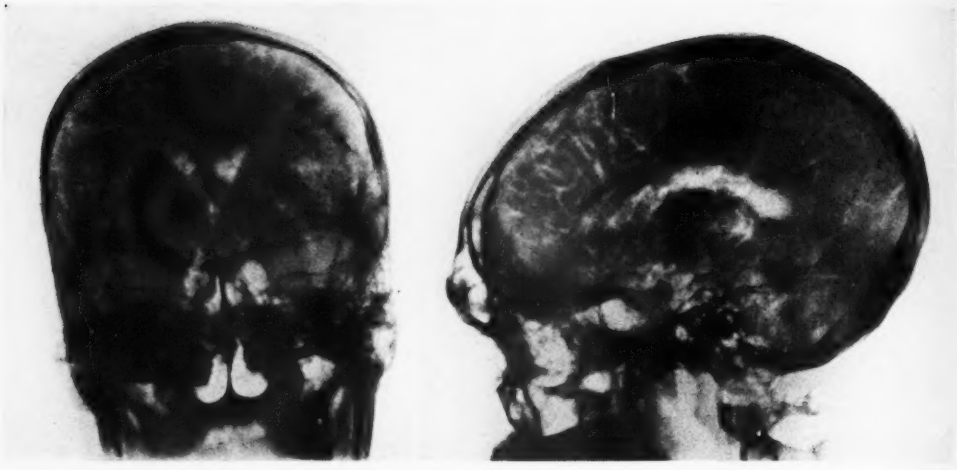


Fig. 22 (*left*) and Fig. 23 (*right*). Post-traumatic epilepsy, with arachnoiditis on the left, and cortical atrophy on the right. Operative verification showed diffuse collections in the subarachnoid spaces, with arachnoiditis in the right motor areas secondary to trauma.

possibilities for encephalography, and the danger of the procedure becomes very slight if the precautions already mentioned have been observed. It is evident we are less likely to have lesions involving the cerebral hemispheres that can obstruct the important outlets from the ventricles and thus offer distinct dangers to spinal drainage.

The diagnosis and interpretation of lesions affecting the cerebral hemispheres rest upon the knowledge of the normal pathways for cerebrospinal fluid and their size and distribution. Figures 6-*A* to 6-*H* give diagrammatic representations of the course taken by fluid to reach the vertex, its chief area of absorption. It is evident that as the many fluid channels diverge from the cisterna chiasmatis at the base, it would require a very large tumor to produce obstructive signs and pressure. An inflammatory process would easily block many channels and readily produce symptoms.

Encapsulated tumors here, such as endotheliomas, may reach large proportions before producing signs of pressure, focal signs appearing frequently before the headache, vomiting, and choking of the discs (Fig. 12). This is due to the fact that a solid tumor mass, for instance in the right lower motor area (Sylvian fissure, Fig. 6-*H*), obstructs the channels for fluid at this point, but as there are many other pathways still open (*viz.*, between the frontal lobes, anteriorly over the frontal pole, the opposite side, etc.), the tumor may continue to enlarge until by its added volume and the compensating shift of the brain structures there is a constant cutting down in size of the compensatory pathways (Figs. 13 and 14). The time arrives when fluid can no longer reach the vertex easily, and back-pressure begins. This produces a vicious circle in that with the increased pressure back toward and into the ventricular system the cortical surface of the brain is pressed against the dura and skull, with further obliteration of the fluid spaces and channels. This results in great deficiency in circulation of fluid and a further rise in pressure. Generalized symptoms of intracranial pressure ensue. Such a lesion produces an encephalographic study such as is seen in Figure

Fig. 24. Compensatory pathways of the vertex in a case of abnormal calcification over the frontal region. Evidence of arachnoiditis in the parietal area. Patient had chronic headache throughout life; history of many falls from horse.

Fig. 25. Lateral view showing area of decompression following trauma. Thirteen years later patient developed convulsive seizures, but has maintained civil service position in a post office to the present time. Extensive cerebral atrophy, with dilation of the cisterna venæ magnæ cerebri.

11, with dilatation of the cisterna chiasmatis and failure to fill or drain the cortical pathways, due to obliteration or blockage. A few compensatory pathways may be found to still remain. The obliteration of an area of usual fluid spaces indicates either trapped fluid or pathways filled with reactive or inflammatory tissue (arachnoiditis, *e.g.*, Fig. 15). The size and location of the tumor can be determined in the stereoscopic views when the ventricular distortions, combined with the characteristic lack of cortical air markings, indicate the location and extent of the lesion (Fig. 16).

Gliomas produce a somewhat different mechanism of pressure, and hence an encephalographic study that is quite diagnostic. As gliomatous tumors are invasive and produce a reactive gliosis as they spread, they increase the bulk of the brain in such a way that the convolutions become larger and are pressed more closely together, thus obliterating the fluid pathways in the sulci between them (Fig. 16). A soft, flattened, yellowish surface is characteristic of glioma when viewed at operation. In the "ironing out" of the cortex by the glioma the fluid spaces are decreased. The volume of the hemisphere enlarges and frequently extends across the midline (Fig. 17). The increased volume displacement soon affects spaces on the normal side and a point is reached when compensation no longer occurs.

Pressure beginning in this type rapidly increases and produces permanent mechanical obliteration of channels, which do not reestablish themselves even after removal of a mass of the tumor or after decompression. The discouraging aspect of the glioma problem has been the failure to overcome the final pressure factors, even after a good decompressive opening and ample removal of tumor mass. The early recognition of these lesions before these changes have reached a permanent state is offered by encephalography, and the safety of the procedure when undertaken before the high pressure stage appears has been well demonstrated.

Beside the usual obliteration of the fluid spaces in a glioma case the ventricular out-

Fig. 26. Anteroposterior view showing marked atrophy of both hemispheres in a case of post-traumatic epilepsy. Note enlargement of the cisterna venæ magnæ cerebri, midline cortical air markings, and area of decompression at the site of injury (fifteen years prior to encephalogram).

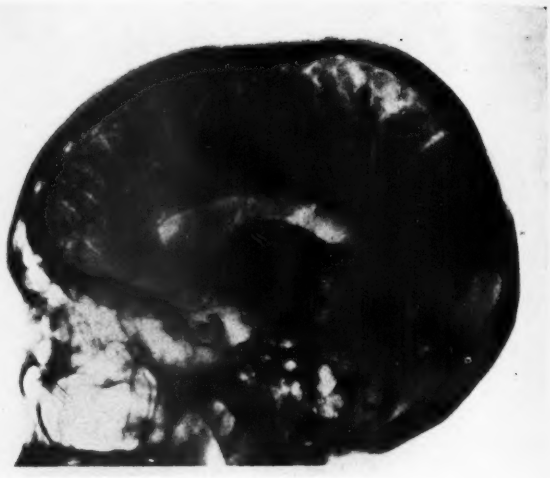


Fig. 27. Focal cortical atrophy present in the parietal area in a case of epilepsy.

line may be well preserved, but the shape diminished as though by a general invasion to its walls (Fig. 16), thus reducing the outline. If a cystic mass be present, the same distortion noted in the solid encapsulated tumor results.

The differential diagnosis between areas of inflammatory obliteration and glioma when seen on the encephalogram lies mainly in the study of the ventricular spaces and the cisternæ. Inflammatory reactions if subacute or chronic give rise to the generalized increased collections of fluid behind the point of obstruction, so that the ventricles and cisternæ appear to be slightly enlarged, and instead of being distorted or obliterated actually show evidence of loss of brain volume by increase in size (Fig. 18). In such cases the areas showing loss of cortical air markings indicate either undrained fluid (trapped) or adhesive arachnoiditis (plastic exudate). This type is fairly frequent, especially among the post-traumatic, paretic, epileptic, birth injury, and mental defective cases (Figs. 19 and 20).

ARACHNOIDITIS

The process of arachnoiditis is recognized grossly at operation by a milky appearance of the arachnoid covering the cortex. It is found to be thickened and the layers of the pia and arachnoid are fused together by reactive tissue in such a way that the pathways for fluid are greatly impaired. These areas may appear cystic, as described by Dandy (9), and with the increase in fluid around them there are deepening and widening of the sulci, with evidence of actual convolutional atrophy (Fig. 21). At times the process is diffuse, so that a generalized edema is present, and fluid is held within the meshes of the spongy arachnoid patches in such a way that it is *impossible to drain it by the lumbar route.* Even with the direct operative exposure of these areas and the opening of the arachnoid it is difficult to dislodge these fluid collections even by gentle massage of the edematous area and

stroking the fluid toward the arachnoid opening. In dealing with this type of trapped or edematous collections of fluid one is reminded of soggy wet bread. In several instances operative exploration has immediately followed encephalography and the areas where no air appeared on the roentgen films have showed that fluid remained undisturbed at these points though air was present in the open channels surrounding them (Figs. 22 and 23). The diagnostic interpretation of these undrained and obstructive areas rests with the history of the case or the advanced signs of atrophy present, suggesting an old lesion, possibly of traumatic or inflammatory origin (Fig. 18). The appearance in the encephalogram may indicate arachnoiditis, but the roentgenologist should bear in mind that the area may contain a large amount of trapped fluid, thus disguising the underlying atrophy (Fig. 19).

In some cases (Fig. 24) compensatory channels arise to allow fluid to find other pathways to the vertex when the normal fields have been blocked. We have seen one such case in which no air appeared over the fronto-parietal field on either side, but a large pathway had developed posteriorly by way of the cisterna venæ magnæ cerebri and thence between the occipital lobes, to reach the mid-hemispheric region above the corpus callosum from behind (Fig. 11). Such a compensatory mechanism arising after a block in the fluid pathways leading from the cisterna chiasmatis would seem to explain the absence of pressure symptoms which usually occur when no progress for fluid exists in the normal channels.

POST-TRAUMATIC CHARACTERISTICS

The post-traumatic group gives rise to two types of characteristic findings of various degrees. Subarachnoid hemorrhage produces not only organization at the site of the clot but also, according to the work of Weed (29, 30) and the pathological studies of Bagley (1), to an intense reaction of the pia-arachnoid due to the presence of red blood cells. Fibrosis follows the period of reaction and the normal free fluid spaces become sealed off or greatly obstructed in this process. The neuropathological studies of Winkelman (37, 38) confirm these experimental observations as actually present in man. The encephalogram shows little or no air in these areas, but generalized enlargement of the fluid pathways at a distance as though obstruction of cerebrospinal circulation to the vertex had produced back-pressure and dilation of the fluid spaces behind the point of obstruction (Figs. 20, 25, 26, 27, and 28).

When trauma has actually destroyed brain tissue by its force, gliosis and fibrosis in time lead to contracture of the brain. It is in this group that we may see the wall or roof of the *ventricle drawn toward the surface of the brain* (Fig. 18). The surface markings may show evidence of obliteration at this point (Fig. 18), or, if marked loss of brain has occurred, there may be great atrophy of the cortex, as shown by increase in the air markings associated with a dilated ventricle on the side of the atrophy. This is particularly true in thrombotic lesions; the gross pathology of ventricular enlargement and cortical atrophy is clearly shown in a study of Figures 28, 29, and 30.

The differentiation between mass lesions such as tumor, cyst, or abscess is best shown in the study of Figures 13, 14, and 16, as compared to Figures 15 and 18. Here filling defects and distortion of the ventricles occur but always *away* from the site of the lesion, frequently with a shift of the midline structures to the opposite side. If a solid tumor of sufficient size is present, it will not only obliterate the fluid spaces over the cortex where it is situated but may depress the wall of the ventricle and by stereoscopic

study of the encephalographic films give definite evidence of its relative size and location.

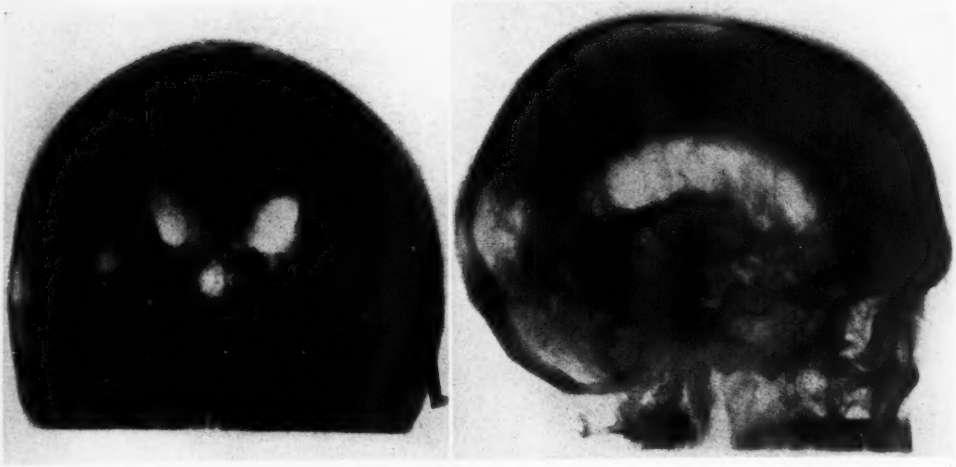
As has been already pointed out glio-

Fig. 28. Anteroposterior view showing slight cortical atrophy (unilateral), with increase in cortical air markings on the opposite side. Normal ventricles.

matous tumors are invasive and swell the bulk of the hemisphere in such a way as not only to obliterate the cortical markings by flattening the cortex and filling in the fluid pathways normally present in the sulci between the convolutions, but also to encroach upon the ventricular lumen, producing a small or deformed ventricle.

GENERALIZED BRAIN ATROPHY

When the obstruction occurs at the outlets for cerebrospinal fluid along the longitudinal sinus and the large veins, we observe



Figs. 29 (*left*) and 30 (*right*). Encephalograms in case of progressive mental deterioration and blindness. Speech became indistinct, there was loss of orientation and judgment, with gradual paralysis. No choking of the discs; Wassermann negative. Note the generalized arachnoiditis over the frontal lobes, with one remaining compensatory pathway.

In the anteroposterior view the ventricles are shown dilated but on each side is an increased collection of air in the region of the Island of Reil.

The lateral view shows not only the atrophied area in the Island of Reil, with irregular cyst-like collections of air, but more striking is the marked atrophy of the occipital pole in the region of the cuneus. This, we believe, accounted for the blindness, the speech defect being due to the atrophy in the Island of Reil area, and the frontal lobe signs of mental failure to the arachnoiditis.

As the patient had increased spinal pressure a brain tumor was suspected until the encephalogram showed the multiple areas of atrophy, accounting for the symptoms described.

increase in the fluid spaces behind this point, with dilatation of the pathways over the parietal and frontal area and typical cerebral atrophy. It should be noted that the atrophy is almost always confined to this area, no matter what the cause for disturbance in the final outlets for fluid may prove to be. This atrophy, so typical in the mental defective and imbecile groups, whether due to birth injury, meningitis, or trauma in later life with subarachnoid hemorrhage, has been shown by Winkelman to have in common marked deficiency or destruction of the Pacchionian system (Figs. 19, 20, 25, 26, 27, and 28).

We have discussed elsewhere (21) the question of hydraulics producing this type of atrophy, which we believe to be a pressure atrophy of the ischemic type. The fluid spaces of the fronto-parietal areas communicating as they do grossly may permit a "fluid cast" to encase this area of the brain, and this "fluid cast" registers constantly the various changes of pressure within the closed skull on the walls of the pathways (*i.e.*, the fronto-parietal convolutions). This we believe would produce a pressure atrophy on the soft tissue of the brain similar to the pressure atrophy we see in the soft tissues of the extremities when a close-fitting cast is applied to the part. There seems no other plausible explanation for the selective atrophy which is so frequently closely confined to this area of the brain when compared to the adjacent temporo-occipital areas, the only striking differences morphologically be-

Figs. 31 (*left*) and 32 (*right*). Epilepsia tarda in a woman of forty-five. Note calcification of the Pacchionian bodies on each side of the midline: slight atrophy in the region of the Island of Reil: cerebellar atrophy.

ing the presence of these gross fluid channels normally in the fronto-parietal region and their absence in the temporo-occipital area.

The interpretation which we have placed upon the finding of enlarged fluid spaces and increase in the size of the air shadows over this portion of the brain is not only one of cerebral atrophy, but that a deficiency, block, or degenerative change has taken place at the portals of elimination for cerebrospinal fluid, the exact nature of which depends upon the history and physical findings of the case.

The pathological changes noted by Winkelman (37, 38) in the Pacchionian bodies, associated with increased fluid accumulation and consequently cerebral atrophy, are (*a*) aplasia, congenital absence of these structures; (*b*) hypoplasia, infantile type, with marked failure of proper development; (*c*) hyperplasia, acutely swollen and enlarged Pacchionian bodies, found in toxic, eclamptic edema; (*d*) infiltrative invasion of the structures by red cells, leukocytes, inflammatory tissue, and occasionally cancer cells; (*e*) sclerotic, degenerative changes, with shrinkage of the structure, a loss of its characteristic architecture and its replacement by fibrous tissue and calcium deposits.

Calcification of the Pacchionian bodies has been noted as a fairly constant finding in later life, but our encephalographic studies would seem to indicate that in cases in which the process was marked it was associated with increased fluid accumulations over the fronto-parietal area and at the vertex (Figs. 31 and 32). The patients often show mental changes, with signs of deterioration.

The Island of Reil is frequently seen in cases of advanced atrophy involving the Sylvian area (Figs. 7, 20, 29, and 30). It is usually associated with deficiencies in speech, especially if involved on the right side in left-handed individuals. In the ster-

eoscope one may see the shrunken convolutions and this is evidence of the external hydrocephalic type (Fig. 30). Where no convolutional markings are seen and air is increased, especially with loss of the temporal lobe definition, a vascular thrombotic lesion is usually responsible for this finding (Figs. 30, 33, and 34).

SUMMARY

It has been our purpose to trace the path-

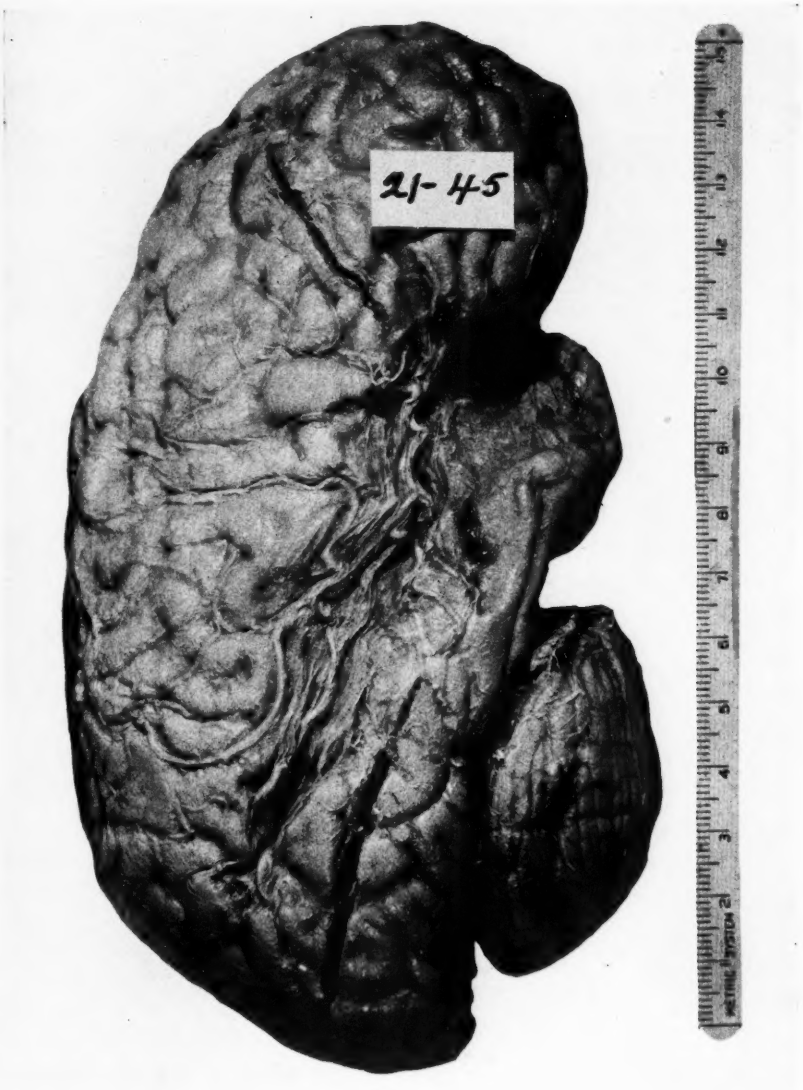


Fig. 33. The appearance of a thrombotic lesion showing gross loss of brain structure and atrophy, including the temporal lobe. Note in this type of lesion that there is no gross enlargement of the fluid pathways over the frontal lobe or even in the field of atrophy. The process is not similar to the obstructive arachnoiditis type although it may lead to extensive brain atrophy, which is characteristic of a general loss of cerebral architecture. (Preparation by Dr. N. W. Winkelman.)

ways for cerebrospinal fluid circulation as we understand them at the present time, pointing out the roentgenological significance as shown when cerebrospinal fluid is replaced by air.

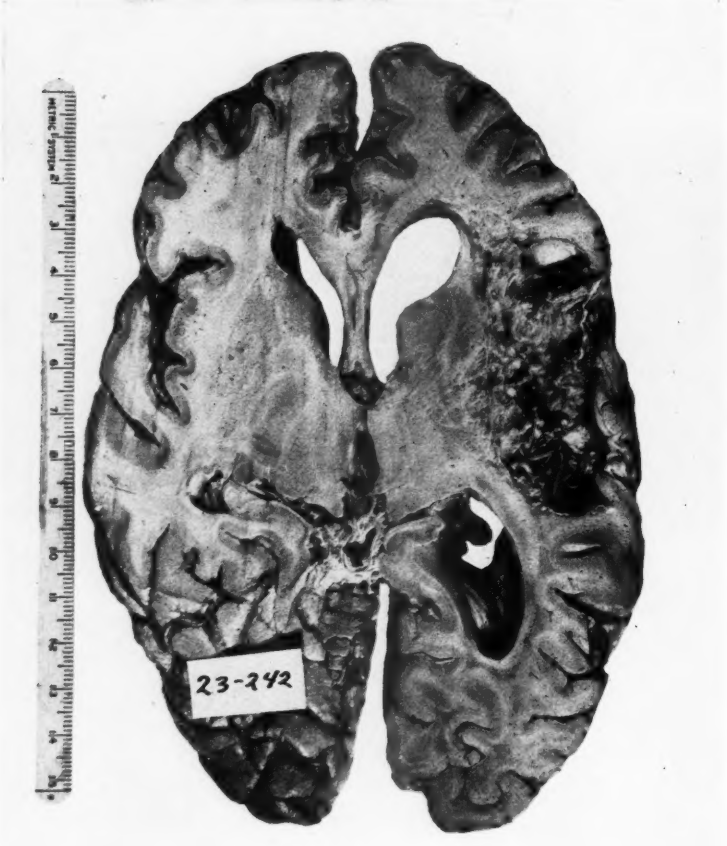


Fig. 34. Cross-section of a brain with a thrombotic lesion showing contracture of the brain substance, enlargement of the ventricles on the side of the lesion with sulci uninvolved in the neighborhood of the degeneration. Cortical atrophy is characterized by a loss of convolutional markings. (Preparation by Dr. N. W. Winkelman.)

The interpretations of these air shadows are based upon the knowledge of neuro-anatomical relationships and the changes from the normal which occur when obstructive lesions exist along the course of these fluid pathways from their origin to their points of elimination.

The correlation of neurosurgical verification as well as neuropathological studies has justified the interpretations and mechanical considerations described above.

The indications, contra-indications, and diagnostic value of the procedure have been

discussed, and its definite use in many cases where focal signs are not clear-cut or obscure symptoms referable to the brain require clarification pointed out.

Figs. 35 (*left*) and 36 (*right*). Idiopathic epilepsy of three years' duration. Note the increase of air in the midline and at the vertex, associated with beginning frontal pole atrophy.

DISCUSSION

The procedure has demonstrated unsuspected gross lesions in the post-traumatic and birth injury groups, as pointed out by one of us (21). The cases of idiopathic and symptomatic epilepsy have shown gross atrophy in almost every case so far studied by the encephalogram, if symptoms have been present for a year or more (Figs. 35 and 36). Cases presenting mental deterioration (Figs. 7, 25, 26, 29, and 30), dyskinesia (Figs. 18, 19, and 20), chronic headache (Figs. 37 and 38), vertigo, and post-traumatic neurosis (Figs. 25 and 26) have revealed definite evidences of gross cerebral deformity as demonstrated by the encephalogram.

The need for careful selection of cases with signs of brain tumor has been pointed out, but the evidence obtained in *cerebral* tumors especially has made localization the more exact and determined the better selection of an operative procedure to meet the actual requirements of the individual case. The risk in this type of case is undoubtedly higher than in any of the other groups, but it is our distinct impression that the risk assumed is less than that in ventriculography and no greater than lumbar puncture with withdrawal of fluid for diagnostic purposes.

The gliomatous tumor frequently produces rapidly fatal symptoms spontaneously or with a slight disturbance of the pressure mechanism after a lumbar puncture, exploration, ventriculography, or encephalography.

A survey of 1,529 cases of encephalography in this country and abroad showed a mortality of 20 when followed to a three-months post-operative period (1.2 per cent). Three deaths were reported in cases of glioma, two in cerebellar tumors, five with internal hydrocephalus, and the remainder occurred in conditions such as premature infants, meningitis, alcoholic and paralytic patients, evidently poor risks. Approximately 85 per cent of the deaths reported were from

Figs. 37 *(left)* and 38 *(right)*. Anteroposterior and lateral views of chronic case of cephalalgia simulating migraine; unknown origin. Note increase in size of cortical air markings and evidence of chronic external hydrocephalus.

foreign clinics, and it was evident that encephalography was used in cases where contra-indications existed or the condition of the patient did not warrant the procedure.

The value of encephalography as an important adjunct to diagnosis lies in its use where indications are clear-cut after careful study of the case from the neurological standpoint. The technic of the procedure of air injection must be carried out with exacting regard for changes in intracranial pressure and proper manipulation of the patient during the procedure. The roentgenological technic must be uniform and exact, to produce roentgenograms which are capable of interpretation. The standardization of both procedures makes possible a basis for interpretation which has proved of distinct clinical value. Only by such measures is it possible to correlate a series of cases and compare the findings with other groups as a basis for constructive analysis.

CONCLUSIONS

1. Encephalography has proved to be a diagnostic procedure of great importance when properly carried out.

2. The procedure of air injection must be carefully carried out by one familiar with the objects of the operation (drainage of the subarachnoid and ventricular spaces), with due regard to the importance of intracranial pressure changes and the indications and contra-indications presented in the cases selected.

3. The roentgenographic technic must be undertaken by a standardized and constant method so as to produce perfect roentgenograms which can be duplicated at subsequent examinations or can be utilized for making comparisons between different examinations.

4. The correct interpretation of the roentgenograms is possible only when the procedures both of air injection and

roentgenography have been perfectly carried out.

5. The diagnosis by the encephalographic findings requires an understanding of the neuro-anatomical relationships as seen in three dimensions and familiarity with gross neuropathological changes frequently encountered and giving rise to obstruction or distortion of the cerebrospinal fluid circulating pathways.

We wish to express our appreciation to those who have co-operated in making possible the presentation of these observations, especially to Dr. William G. Spiller and Dr. Eugene P. Pendergrass for clinical assistance; to Dr. Daniel J. McCarthy for the resources of his foundation, and to the neuropathological studies of Dr. N. W. Winkelman we are greatly indebted. Also to Dr. C. H. Frazier and Dr. M. Feldstein for the use of several illustrative cases.

BIBLIOGRAPHY

(1) Bagley, C., Jr.: Blood in the Cerebrospinal Fluid: Resultant Functional and Organic Alterations in the Central Nervous System: Experimental Data. Arch. Surg., July, 1928, XVII, 18.

(2) Bateman, J. Fremont: Closed Foramina of Luschka in the Brains of the Insane: Their Influence on the Pathogenesis of the Psychoses. Arch. Neurol. and Psychiat., November, 1925, XIV, 616.

(3) Dandy, Walter E.: Ventriculography Following the Injection of Air into the Cerebral Ventricles. Ann. Surg., 1918, LXVIII, 5.

(4) Idem: Roentgenography of the Brain after the Injection of Air into the Spinal Canal. Ann. Surg., October, 1919, LXX, 397.

(5) Idem: Ventriculography Following the Injection of Air into the Cerebral Ventricles. Am. Jour. Roentgenol., January, 1919, VI, 26.

(6) Idem: Localization or Elimination of Cerebral Tumors by Ventriculography. Surg., Gynecol. and Obst., April, 1920, XXX, 329.

(7) Idem: The Diagnosis and Treatment of Hydrocephalus Resulting from Strictures of the Aqueduct of Sylvius. Surg., Gynecol. and Obst., October, 1920, XXXI, 340.

(8) Idem: The Cause of So-called Idiopathic Hydrocephalus. Bull. Johns Hopkins Hosp., March, 1921, XXXII, 67.

(9) Idem: The Space-compensating Function of Cerebrospinal Fluid: Its Connection with Cerebral Lesions in Epilepsy. Bull. Johns Hopkins Hosp., August, 1923, XXXIV, 245.

(10) Idem: Impressions of the Pathology of Epilepsy from Operations. Am. Jour. Psychiat., January, 1927, VI, 519.

(11) Dandy, Walter E., and Elman, R.: Experimental Epilepsy. Bull. Johns Hopkins Hosp., January, 1925, XXXVI, 40.

(12) Encephalographic Committee: Report of Encephalographic Committee before the 30th Annual Meeting of the American Roentgen Ray Society, New York, September 16-20, 1929.

(13) Fremont-Smith, Frank: The Nature of the Cerebrospinal Fluid. Arch. Neurol. and Psychiat., March, 1927, XVII, 317.

(14) Fay, Temple: Administration of Hypertonic Salt Solutions for Relief of Intracranial Pressure. Jour. Am. Med. Assn., May 19, 1923, LXXX, 1445.

(15) Idem: Comparative Values of Magnesium Sulphate and Sodium Chlorid for Relief of Intracranial Tension. Jour. Am. Med. Assn., March 8, 1924, LXXXII, 766.

(16) Idem: Some Factors in the "Mechanical Theory of Epilepsy," with Especial Reference to the Influence of Fluid, and its Control, in the Treatment of Certain Cases. Am. Jour. Psychiat., March, 1929, VIII, 783.

(17) Idem: The Control of Intracranial Pressure. Jour. Am. Med. Assn., April 25, 1925, LXXXIV, 1261.

(18) Idem: Treatment of Cerebral Trauma. West Virginia Med. Jour., June, 1925, XX, 281.

(19) Idem: Problems of Cerebrospinal Pressure. Surg. Clinics North Am., February, 1924, IV, 227.

(20) Idem: Epilepsy. Clinical Observations on the Control of Convulsive Seizures by Means of Dehydration. Jour. Nerv. and Ment. Dis., May, 1930, LXXI, 481-633.

(21) Idem: Generalized Pressure Atrophy of the Brain, Secondary to Traumatic and Pathologic Involvement of the Pacchionian Bodies. Jour. Am. Med. Assn., Jan. 25, 1930, XCIV, 245-249.

(22) Fay, Temple, and Winkelman, N. W.: Widespread Pressure Atrophy of the Brain and its Probable Relation to the Function of the Pacchionian Bodies, and the Cerebrospinal Fluid Circulation. Paper presented before the 85th Annual Meeting of the American Psychiatric Society, Atlanta, Georgia, May, 1929.

(23) Hassin, George B.: Changes in the Brain in Increased Intracranial Pressure. Arch. Neurol. and Psychiat., December, 1928, XX, 1172.

(24) Pancoast, H. K., and Fay, Temple: Encephalography: Roentgenological and Clinical Considerations for its Use. Am. Jour. Roentgenol. and Rad. Ther., May, 1929, XXI, 421.

(25) Pendergrass, Eugene P.: A New Arrangement of the Bucky Diaphragm for Ventriculography. Am. Jour. Roentgenol. and Rad. Ther., March, 1927, XVII, 358.

(26) Idem: New Arrangement of the Bucky Diaphragm for Encephalography. Am. Jour. Roentgenol. and Rad. Ther., May, 1928, XIX, 482.

(27) Sharpe, W.: Intracranial Hemorrhage in the New-born. Jour. Am. Med. Assn., Aug. 25, 1923, LXXXI, 620.

(28) Weed, Lewis H.: Experimental Studies of Intracranial Pressure. Assn. for Research in Nervous and Mental Dis., December 28, 1927.

(29) Idem: The Cerebrospinal Fluid. Physiol. Rev., April, 1922, II, 171.

(30) Idem: The Cells of the Arachnoid. Bull. Johns Hopkins Hosp., October, 1920, XXXI, 343.

(31) WEED, LEWIS H., and HUGHSON, WALTER: Intracranial Venous Pressure and Cerebrospinal Fluid Pressure as Affected by the Intravenous Injection of Solutions of Various Concentrations. Am. Jour. Physiol., November, 1921, LVIII, 101.

(32) Idem: The Cerebrospinal Fluid in Relation to the Bony Encasement of the Central Nervous System as a Rigid Container. Am. Jour. Physiol., November, 1921, LVIII, 85.

(33) WEED, LEWIS H., and MCKIBBEN, P. S.: Experimental Alteration of Brain Bulk. Am. Jour. Physiol., May, 1919, XLVIII, 531.

(34) Idem: Pressure Changes in the Cerebrospinal Fluid Following Intravenous Injection of Solutions of Various Concentrations. Am. Jour. Physiol., May, 1919, XLVIII, 512.

(35) WEED, LEWIS H., and WEGEFORTH, PAUL: Experimental Irrigation of the Subarachnoid Space. Jour. Pharmacol. and Exper. Therap., July, 1919, XIII, 317.

(36) WEARN, J. T., and RICHARDS, A. N.: Observations on the Composition of Glomerular Urine, with Particular Reference to the Problem of Reabsorption in the Renal Tubules. Am. Jour. Physiol., December, 1924, LXXI, 209.

(37) WINKELMAN, N. W.: Pathological Studies of the Arachnoid Villi and Pacchionian Bodies in Various Types of Convulsive States. Assn. for Research in Nervous and Mental Dis., December 27, 1929.

(38) WINKELMAN, N. W., and FAY, TEMPLE: The Histology and Pathology of the Pacchionian System, with Particular Reference to the Idiopathic and Symptomatic Convulsive State. Paper read before the 55th Annual Meeting of the American Neurological Assn., Atlantic City, New Jersey, May 27-29, 1929.

X-RAY ANALYSIS OF ATOMIC STRUCTURE

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1. INTRODUCTION

THE analysis of crystals by means of X-rays is familiar to most physicists and chemists. The analysis of crystals is effected principally by measuring the angular positions of an X-ray spectrum line of given wave length reflected in different orders by various planes of atoms in the crystal. By means of the powdered crystal method a single exposure enables us to measure the angular positions of all such reflections of a single wave length on a photographic film. The angular positions of the lines on the photograph must be measured accurately but the intensities of the various lines need be known only qualitatively. From the photograph, the arrangement and position of each atom in the crystal is determined.

However, if the intensities of the lines on a powdered crystal photograph are measured quantitatively, it is possible to obtain information as to the arrangement of the electrons in each of the atoms of which the crystal is composed, and thus the atom may be analyzed. Before proceeding with a description of the experiments, we shall give the theory of why it is that the arrangements of the electrons in the respective atoms of a crystal play a part in the intensities of a spectrum line as reflected in different orders.

2. THEORY

In crystal analysis it is assumed that the diffracting centers in a crystal lattice are the atoms. This, however, is not exactly true. It is more correct to say that the electrons of which the atoms are made up are the diffracting centers. If the electrons in an atom are arranged at different distances from the nucleus, then these electrons will not all exactly lie in a lattice plane of the

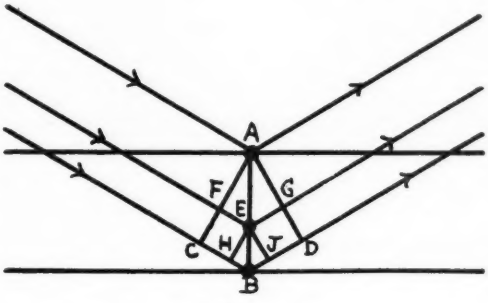

Fig. 1.

crystal even though the nucleus, which is at the center of the atom, does lie in a lattice plane. As a result of this atomic structure, therefore, the electrons will be most thickly concentrated in a lattice plane, but the concentration will not immediately drop to zero at points outside a lattice plane. The electron concentration at a point will probably fall off gradually as the distance of the point from a lattice plane increases.

Let us consider two lattice planes of a crystal as shown in Figure 1. Suppose an electron to be at A in the upper plane and a second electron to be at B in the lower plane, and suppose that the crystal is set at a grazing angle θ which satisfies the Bragg equation

$$n\lambda = 2d \sin \theta \qquad (1)$$

where λ is the wave length of the X-rays, n the order of reflection, and d the grating space, which in Figure 1 is equal to AB. In this position the path difference between the rays diffracted by A and B, respectively, is CB + BD and this must equal $n\lambda$. Suppose,

however, that the electron associated with the lower plane is at E, instead of at B, then the path difference between the rays diffracted by A and E, respectively, is FE + EG, which is less than $n\lambda$ by a length

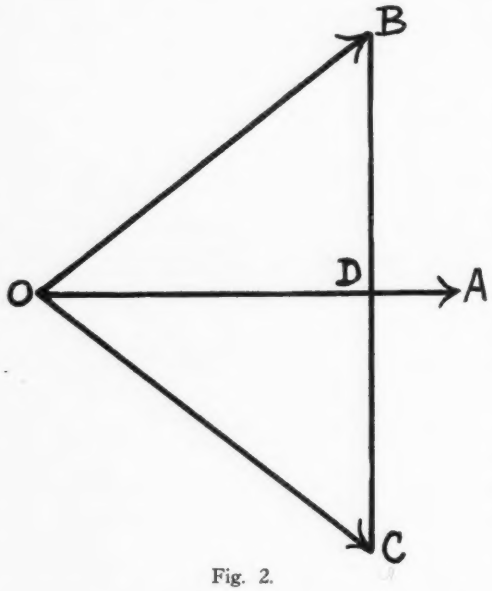

Fig. 2.

HB + BJ. Let BE = z, then HB + BJ = 2z sin θ, so that FE + EG = $n\lambda$ — 2z sin θ. The diffracted ray from E will therefore be out of phase with the diffracted ray from A by an angle $4\pi z \sin \theta/\lambda$. For each electron associated with the lower plane, as in Figure 1, but which is above the plane by a distance z, there will be on the average an electron similarly placed below the plane. Let us represent the amplitude of a wave diffracted by an electron exactly in the lower plane by a horizontal line OA in Figure 2, then the amplitude of the wave diffracted by an electron at E in Figure 1 will be represented by OB where the angle AOB is the phase angle $4\pi z \sin \theta/\lambda$, and the amplitude of the wave diffracted by an electron at a distance z below the plane will be represented by OC where the angle AOC equals the angle AOB. The amplitude of the combined waves diffracted by these two electrons will be represented by 2 OD and this has a phase angle of zero. The amplitude of the combined waves then equals $2a \cos (4\pi z \sin \theta/\lambda)$ where a is the amplitude OA. Hence on the average the amplitude per electron is half this amount, or $a \cos (4\pi z \sin \theta/\lambda)$. The effect of an electron at a distance z from a lattice plane is therefore the same as a fraction $\cos (4\pi z \sin \theta/\lambda)$ of an electron in a lattice plane. This fraction is called the amplitude factor for an electron. If, now, we add the amplitude factors for each of the electrons associated with a plane and divide this sum by the number of atoms associated with that plane, we obtain what is known as the atomic structure factor.

If the probability that an electron associated with a lattice plane is at a distance between z and z + dz from that plane is p(z)dz, then the average amplitude factor A for this electron is given by

$$A = \frac{\int p(z) \cos (4\pi z \sin \theta/\lambda) dz}{\int p(z) dz} \qquad (2)$$

where limits of the integrals are chosen so as to make the integral in the denominator equal to unity. We shall now consider two cases in which the amplitude factor may be easily calculated for the atom.

Electron on a Spherical Shell. A. H. Compton (1) has shown that if the electron is equally likely to be at any point on a spherical shell of radius b and if the center of the shell is in a lattice plane, then $p(z) = 1/2b$ for the range $-b < z < b$, but $p(z) = 0$ for values of z outside this range. The average amplitude factor for the electron now becomes

$$A = \frac{1}{2b} \int_{-b}^{+b} \cos (4\pi z \sin \theta/\lambda)\, dz = \frac{\sin (4\pi b \sin \theta/\lambda)}{4\pi b \sin \theta/\lambda} \qquad (3)$$

This would be the value of the amplitude factor for an electron moving in a Bohr cir-

cular orbit whose plane is equally likely to be oriented in any direction. If there are electrons of different kinds, such as K, L, M, in an atom, the sum of the amplitude factors for each electron in the atom is called the true atomic structure factor f, and hence in the case of the electrons being on shells we have

$$f = \sum_r \frac{n_r \sin(4\pi b_r \sin\theta/\lambda)}{4\pi b_r \sin\theta/\lambda} \qquad (4)$$

where b_r is the radius of the r^{th} shell and n_r is the number of electrons in the r^{th} shell. The right side of Eq. (4) may have a negative value and it is difficult to obtain a negative value for f experimentally, as will be seen later. In recent years, however, physicists have abandoned the Bohr model and have tended to adopt the wave-mechanical model of Schrödinger (2), which we shall now consider.

Schrödinger's Model of the Hydrogen Atom. In this model the electron is neither at a fixed distance from the nucleus nor does it revolve about the nucleus in any particular orbit. Schrödinger's first picture was that the electron was replaced by a continuous distribution of electricity whose density varied with the distance from the nucleus. In the case of the normal hydrogen atom the charge density, ρ, was given by

$$\rho = (e/\pi a_o^3)\exp(-2r/a_o) \qquad (5)$$

where r is the distance from the nucleus and $a_o = 0.53$ Ångström is the radius of the first orbit in the Bohr model. According to more recent ideas ρ in Eq. (5) is not the charge density but a probability function, such that the chance of an electron being in a small volume dV at a distance r from the nucleus is $(\rho/e)dV$ where ρ is given by Eq. (5). Using this interpretation of ρ, the probability that an electron is between two parallel planes at distances z and $z+dz$ from the nucleus, respectively, works out to be

$$\rho(z)dz = (1/2a_o)\exp(-2z/a_o)dz \qquad (6)$$

for positive values of z. In Eq. (6), a_o is to be considered as a parameter distinguishing the various electrons in the atom of a crystal. There is a similar expression with the sign of z changed for negative values of z. Substituting this in Eq. (2) and making the limits of the integrals $\pm\infty$ we obtain

$$A = 1/(1 + 4\pi^2 a_o^2 \sin^2\theta/\lambda^2) \qquad (7)$$

Comparing Eq. (3) with Eq. (7), we notice that whereas A may assume negative values in the former case, it never does so in the latter case.

Effect of Temperature. So far we have considered the simple case where the centers of the atoms are on lattice planes. However, each atom as a whole is subject to thermal agitation and this agitation increases with the temperature of the crystal. The centers of the atoms therefore tend to depart more and more from the lattice planes. Let us consider the simple case where, except for the thermal agitation, the electrons lie in lattice planes. Suppose the electrons to be held in place by elastic forces so that, if an electron is displaced a distance z from a lattice plane, the force of restitution is γz where γ is a constant. If a is the component of the amplitude of thermal vibration of the electron perpendicular to a lattice plane, then $\gamma a^2/2$ is the energy of vibration associated with this direction. According to Boltzman's principle the probability of an electron having an energy between w and $w+dw$ is proportional to $\exp(-w/kT)dw$. Hence the probability of an electron having a component amplitude of thermal vibration between a and $a+da$ is proportional to $a\exp(-\gamma a^2/2kT)da$. The probability that an electron whose amplitude of vibration is a is between distances z and $z+dz$ from a lattice plane is $dz/(\pi\sqrt{a^2-z^2})$ for $z<a$ and zero for $z>a$. The probability that an electron whose amplitude of vibration has any value greater

than z is between distances z and $z + dz$ from a lattice plane is $\rho(z)dz$ where

$$\rho(z) = \text{const} \int_z^\infty \frac{a \exp(-\gamma a^2/2kT)}{\pi \sqrt{a^2 - x^2}} \, da$$

or

$$\rho(z) = \sqrt{\gamma/2\pi kt} \exp(-\gamma z^2/2kT) \quad (8)$$

Finally the average amplitude factor for the electron is

$$A = (\gamma/2\pi kT) \int_{-\infty}^{\infty} \exp(-\gamma z^2/2kT) \cos(4\pi z \sin\theta/\lambda) dz = \exp(-B \sin^2\theta/\lambda^2) \quad (9)$$

where $B = 8\pi^2 kT/\gamma$. This is the form as obtained by Debye (3). It is seen that A depends upon the absolute temperature and upon the elastic constants of the body through γ.

We do not usually think of the thermal vibrations of the electrons which constitute an atom but rather of the vibrations of the atom as a whole. It can be shown that when an atom whose electrons are arranged on a sphere of radius b vibrates thermally, carrying its electrons with it, the average amplitude factor for each electron is

$$A = \frac{\sin(4\pi b \sin\theta/\lambda)}{4\pi b \sin\theta} \exp(-B \sin^2\theta/\lambda^2) \quad (10)$$

In general, the atomic structure factor F consists of two factors—the true atomic structure factor, which is usually represented by f, and the temperature factor, so that

$$F = f \exp(-B \sin^2\theta/\lambda^2) \quad (11)$$

3. EXPERIMENTAL METHODS

W. L. Bragg (4) and his pupils have developed a technic for obtaining what is known as the integrated reflection. A crystal is rotated past the reflection angle θ with an angular speed ω. If the ionization produced in a chamber by the reflected X-rays during the time of turning from one position of no reflection, through the position of reflection to a second position of no reflection, is represented by E and the ionization produced by the primary X-rays in unit time is represented by I, then the integrated reflection at this order of reflection is given by $E\omega/I$.

According to C. G. Darwin (5), the integrated intensity is given by

$$\frac{E\omega}{I} = \frac{N^2 e^4 F^2 \lambda^2}{2m^2 c^4 \sin 2\theta} \cdot \frac{(1 + \cos^2 2\theta)}{\mu} \quad (12)$$

where N is the number of molecules per cubic centimeter of the crystal, θ is the Bragg angle of reflection, λ is the wave length of the X-rays used, e and m are the charge and mass of the electron, respectively, c the velocity of light (inserted because e is in electrostatic units), μ the linear absorption coefficient of the X-rays in the crystal and F is a measure of the diffracting power of the atom. F is also known as the atomic structure factor. All the quantities in Eq. (12) can be measured or are known except F, so that Eq. (12) can be used to determine F. It should, however, be noted that μ is not the ordinary linear coefficient of absorption, because W. H. Bragg (6) has shown that when a crystal is in a position to reflect X-rays its absorption coefficient is abnormally high. The increase in the ordinary absorption coefficient is termed the extinction coefficient by W. L. Bragg (4). Methods for the determination of the extinction coefficient are described in the papers of W. L. Bragg and also in Chapter V of A. H. Compton's "X-rays and Electrons," and will not be further discussed here.

When the experimental values of F as obtained from Eq. (12) are plotted again $\sin\theta$, it is found in the case of rocksalt that the points representing the F values, as they are called in the literature, fall upon two curves, I and II, as shown in Figure 3. The points which fall upon the upper curve are obtained from the integrated reflections of all orders from the even planes and of even orders from odd planes, while the points which fall upon the lower curve are obtained from the integrated reflections of odd or-

ders from the odd planes. In rocksalt, an even plane consists of both sodium and chlorine atoms, while an odd plane consists either of sodium atoms alone or of chlorine atoms alone. In reflections of odd or-

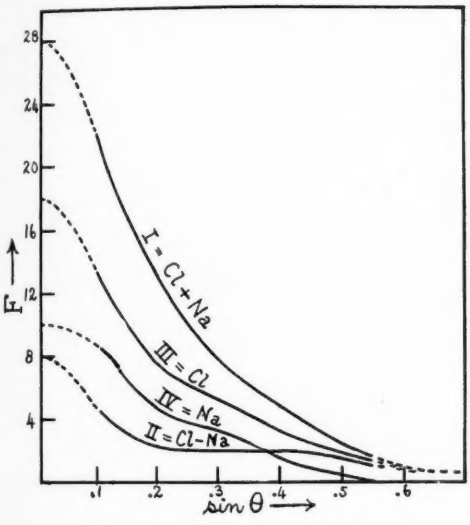

Fig. 3.

der from odd planes, the rays diffracted by the sodium planes are in opposite phase to the rays diffracted by the intermediate chlorine planes and Curve II of Figure 3 is, therefore, called the (Cl — Na) curve. Because the sodium and chlorine atoms cooperate in the even order reflections, Curve I is called the (Cl + Na) curve. Obviously, if we have the F values for (Cl + Na) and for (Cl — Na), we can obtain the curves for the F values of Cl and Na alone by taking respectively half the sum and half the difference of the ordinates of the (Cl + Na) and (Cl — Na) curves. The F curves for Cl and Na alone are shown as Curves III and IV, respectively, in Figure 3. The full portions of the curves in Figure 3 are obtained from experimental values of the integrated intensity, while the broken portions are extrapolations.

Havighurst (7) and Bearden (8) have obtained F values from the intensities of X-rays reflected in different orders and from different planes of powdered crystals. The powdered crystal method has the advantage over Bragg's single crystal method in that when the particles of the powdered crystal are small enough no correction for the extinction coefficient is necessary.

4. INTERPRETATION OF THE EXPERIMENTAL F VALUES

Having obtained the experimental F values for the atoms of a crystal, it is possible to calculate the arrangement of electrons in an atom of the crystal. Two methods are available to us. In the first method, a model of the atom is assumed in which there are certain disposable parameters, such as the radii of Bohr orbits. The f value of the model is determined and then multiplied by the Debye temperature factor. If the values of the parameters can be chosen so that the curve for theoretical F values for different values agrees with the experimental F curve, the problem is solved. If the theoretical and experimental F curves do not agree, then another trial must be made. This method is thus indirect and unsatisfactory. W. Duane (9) and, later, A. H. Compton (10) have developed a second method of unravelling the structure of the atom. This method is analytical and direct. It is known as the Fourier analysis method because it makes use of the same mathematical principle as used in analyzing a periodic motion into its constituent simple harmonic motions. Two formulas are used in this method. The first formula enables us to calculate the number of electrons between planes at distances z and z + dz from a lattice plane in terms of the F values. This number is P(z) dz where

$$P(z) = Z/D + (2/D) \sum_n F_n \cos(2\pi nz/D) \qquad (13)$$

where Z is the number of electrons in the

atom, D is the grating space, and F_n is the atomic structure factor calculated for the n^{th} order reflection from the set of planes whose grating space is D. The disadvantage of Eq. (13) is that the value of Z cannot be obtained from the X-ray analysis. The second formula enables us to calculate the number of electrons between spheres of radii r and r + dr from a lattice point. This number is U(r) dr where

$$U(r) = (8\pi r/D^2) \sum_n nF_n \sin(2\pi nr/D) \qquad (14)$$

A set of F values is shown in Table I.

TABLE I

F VALUES FOR THE ATOMS OF ROCKSALT
D = 3.25 Ångströms
sinθ for first order = 0.109

n	F_n		n	F_n	
	Cl	Na		Cl	Na
1	13.60	8.80	5	2.10	0.10
2	7.84	5.46	6	1.15	0.00
3	5.15	3.05	7	0.31	
4	3.40	0.72			

From the F values, shown in Table I, the radial distributions, U(r), of the electrons can be found for the chlorine and sodium atoms in rocksalt. These are shown in Figure 4. The position of the maximum of each of the humps gives the distance of each different group of electrons from the center of the atom, while the area under each of the humps gives the numbers of the electrons in the respective groups. Thus in the sodium atom there are 8 (K + L) electrons at 0.35 Ångström and 2L electrons at 0.85 Ångström from the average center of the atom. The term "average center" is used because the atom is subject to thermal vibrations. The K and some of the L electrons are merged together because of the thermal vibrations. If the constant B in the Debye temperature factor, $\exp(-B\sin^2\theta/\lambda^2)$, can be determined, the true atomic structure factor f can be obtained by dividing F by the Debye factor. Substituting these f values in Eq. (13) in place of the F values, a radial distribution or U curve can be obtained for an atom which is not subject to thermal

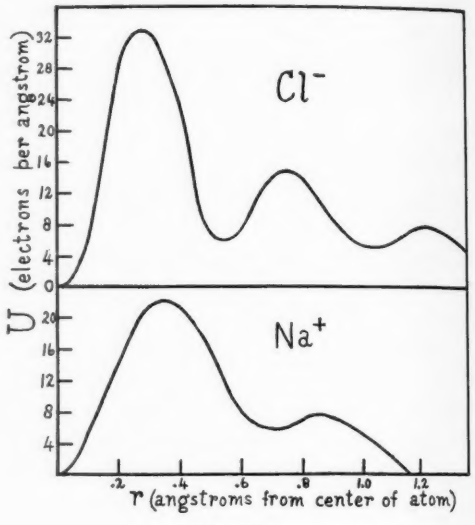

Fig. 4.

vibrations. Such a procedure is usually not followed because of the uncertainty of the exact value of B in the temperature factor. In Section 2 of this article we obtained B in terms of γ for a simple case. Debye (3) and Waller (11) have considered the temperature factor and have obtained B in terms of the "characteristic temperature" of the crystal. However, Waller's formula for B gives B twice the value which is obtained from Debye's formula. Hence, experiments on the temperature factor are necessary and we now proceed to consider these.

5. EXPERIMENTS ON THE TEMPERATURE EFFECT

As early as 1914 W. H. and W. L. Bragg (12) found that the intensity of X-rays reflected by rocksalt decreased with rise of temperature in a way which agreed quali-

tatively with Debye's formula. Later, in 1922, Backhurst (13) attacked the problem again, using temperatures ranging from 15° C. to 950° C. In Backhurst's experiments the crystal was placed inside an electric heater, furnished with mica windows suitably placed to allow of the ingress and egress of the X-rays. The space inside the heater and surrounding the crystal was filled with a nitrogen atmosphere and the temperature was measured by a thermocouple. Backhurst used crystals of aluminum, carborundum, graphite, diamond, and ruby. For the first three a decrease in intensity with increase of temperature was observed in qualitative agreement with Debye's formula. No decrease in intensity was found for diamond, but diamond has a high characteristic temperature and Debye's formula gives a very small change in this case for the temperatures used. Ruby was somewhat anomalous but again the effect was qualitatively in agreement with the formula. In 1924, Collins (14) applied the powdered crystal method to aluminum foil, the wave length of the X-rays being 0.71 Ångström. The intensity of the rays reflected from the (100), (110), (111), and (311) planes was measured for temperatures of 80°, 310°, and 600° C. As the temperature increased the reflection maxima appeared at smaller angles due to expansion of the crystal. This effect was also found by the previous experimenters. Collins found a decrease in intensity with rise of temperature. The decrease was found to be greater than that given by Debye's formula. The effect of temperature as we have seen in Section 2 of this paper is to cause the crystal planes to become more diffuse and less distinct. Collins' results therefore show that the planes lose their distinctness more rapidly with rise of temperature than according to Debye's theory. However, the decrease will be more rapid according to Waller's formula and so Collins' results are more in accord with this later formula.

In 1925, James (15) found that the decrease in intensity for rocksalt in the temperature range 17° C. to 627° C. was much greater than Debye's formula predicted but was in accord with Waller's formula. In 1926, James (16) extended the investigation to temperatures below room temperature and down to approximately liquid air temperatures. In these experiments the crystal was held in a stout brass holder, suspended by means of a hard rubber rod just above the liquid air surface in a Dewar flask. The Dewar flask was made of borosilicate glass which was so thin as to transmit 70 per cent of the radiation. By decreasing the temperature the intensity of the higher orders of reflection increases considerably. For example, the fifth order spectrum was nearly 3.4 times as intense at —185° C. as at room temperature. The results again agree more closely with Waller's formula than with Debye's. For high temperatures the curve falls off too rapidly for either theory, and in all probability this denotes that the elastic properties of the crystal are here changing as the melting point is approached. For low temperatures the intensities are somewhat lower than Waller's theory requires.

In 1927, James and Firth (17) conceived the idea of testing the reflections from both the odd and even planes and of obtaining F curves for different temperatures. They found that there was a different temperature factor for the (Cl + Na) and (Cl — Na) curves. They were then led to postulate different temperature factors for the chlorine and sodium atoms. Instead of the atomic structure factor being given by Eq. (11), it is given by

$$F = f_1 \exp(-B_1 \sin\theta^2/\lambda^2) \pm f_2 \exp(-B_2 \sin^2\theta/\lambda^2) \quad (15)$$

where f_1 and B_1 relate to chlorine and f_2 and B_2 to sodium. The plus sign is used for the

(Cl + Na) curve and the minus sign for the (Cl — Na) curve.

James and Firth use Eq. (13) and arrive at the distribution of electrons between planes. These distribution curves are obtained for various temperatures and an extrapolation is made to absolute zero. From the way the distribution curve varies with temperature James and Firth find the average amplitude of the thermal vibrations to be 0.20 and 0.23 Ångström for the chlorine and sodium atoms, respectively, when the temperature of the rocksalt is 17° C. The average amplitude of the thermal vibrations of both kinds of atoms at 627° C. is 0.58 Ångström. Thus by means of X-ray analysis we can, as it were, watch the increase of the amplitude of thermal vibration of the atoms as the temperature increases.

A complementary problem to that of the intensity of X-rays regularly reflected from crystals is that of the intensity of diffusely scattered X-rays. In addition to the reflected X-rays which are given by Bragg's law, there is diffuse scattering in all directions from a crystal. According to Debye's theory (3) the intensity of the diffuse scattering from a crystal increases with the temperature at the same time as the intensity of regular reflection decreases. Debye's theory requires that the intensity of the diffuse scattering shall be proportional to $[1—\exp(—B \sin^2\theta/\lambda^2)]$ where θ is now one-half the angle of scattering. In 1922, Jauncey (18) made experiments on the diffuse scattering from rocksalt and calcite at temperatures of 17° C. and 295° C. Jauncey found no increase in the intensity of the X-rays diffusely scattered by calcite, and only a small, and possibly no, increase in the case of rocksalt. These results are definitely not in accord with the Debye theory. In Debye's theory, the effect of an increase in temperature is to produce a more random distribution of the electrons. The Thomson (19) theory of the diffuse scattering of X-rays assumes a random distribution of electrons in the scattering substance. This theory gives a formula which is in fairly good agreement with the observed intensity of scattered X-rays from amorphous substances as shown by Barkla (20) and others. It therefore seems reasonable to suppose that as a crystal approaches an amorphous body, at least as far as its electron distribution is concerned, the crystal would scatter more like an amorphous substance, whereas the fact is that the temperature factor for diffuse scattering is either zero or very much smaller than the factor as derived by Debye. However, the diffusely scattered X-rays from crystals exhibit the Compton effect, that is, a change of wave length on scattering. The Compton effect is not taken into account in the Debye theory and this is one reason for the lack of agreement between theory and experiment.

It should be noted that Debye obtains two formulas for B in Eq. (11). The one formula is for the case where zero point energy is assumed and the other formula for the case of no zero point energy. Planck introduced the idea of zero point energy in his quantum theory of radiation. Zero point energy is the energy still existing in an oscillator at absolute zero. Its value is half a quantum of energy per degree of freedom. Neither of Debye's formulas agree with experimental results for diffuse scattering although they agree qualitatively with the results for regular reflection.

6. THE STRUCTURE OF THE ATOM

In 1928, James, Waller, and Hartree (21) attacked the problem of the interpretation of the experimental F curves from the point of view of Schrödinger's theory of the distribution of electrons in the atom. Their method was to devise a Schrödinger model similar to that described for hydrogen in Section 2 of this paper, although the

model for an atom like chlorine or sodium is much more complicated than the model for hydrogen. They were able to devise approximate methods for constructing the models and then to calculate the f curves for model atoms in a crystal. These f curves are then multiplied by their respective temperature factors as in Eq. (15), and theoretical F values obtained. These theoretical F curves were found to agree with the experimental F curves. They prefer this method of attack to the Fourier analysis method because of the uncertainty of the F values for the higher orders of reflection. The U (*i.e.*, radial distribution) curves for Na^+ and Cl^- are given in their paper. The Na^+ curve has humps at about 0.05 and 0.33 Ångström and the Cl^- curve humps at 0.04, 0.18, and 0.85 Ångström from the center of the atom. These U curves are for atoms which have no thermal vibrations. It is seen, therefore, that although in recent physical theory the idea of the electrons of an atom being located on definite shells has been abandoned, yet the electrons do tend to congregate at certain distances from the center of the atom.

James, Waller, and Hartree found it necessary to assume some heat motion at absolute zero, the amount of energy required being that of Planck's zero point energy. Combining this assumption with the assumption of Schrödinger distribution, they obtained better agreement with the experimental F values. Also they obtained better agreement when they assumed chlorine and sodium ions than when they assumed neutral atoms. It seems, therefore, that the structures of the atoms in rocksalt have been completely evaluated.

In 1928 James and Brindley (*22*) obtained experimental F values for sylvine (KCl) and applied the method of James, Waller, and Hartree in order to obtain the electron distributions in potassium and chlorine. It was, as in the case of rocksalt, found necessary to assume zero point energy and also to assume that the potassium and chlorine exist as the ions K^+ and Cl^-. The radial electron distribution of K^+ has humps at about 0.04, 0.15, and 0.62 Ångström. The humps for Cl^- occur at about 0.04, 0.17, and 0.78 Ångström. The average amplitudes of the thermal vibrations of the potassium and chlorine atoms are equal at the same temperature and are 0.15 and 0.26 Ångström at —187° C. and 17° C., respectively. In the case of rocksalt the amplitudes are different for the different atoms but in sylvine the masses of the potassium and chlorine atoms are so nearly equal that there is no difference between the amplitudes at the same temperature.

In 1929 James, Brindley, and Wood (*23*) obtained experimental F values for X-rays of wave length 0.71 Ångström reflected from aluminum crystals. The importance of this experiment is that, whereas rocksalt and sylvine both consist of two kinds of atoms, a crystal of aluminum consists of only one kind of atom. Both Debye's theory and Waller's modification (11) of Debye's theory are applicable only to cubic crystals of one kind of atom. James, Brindley, and Wood conducted their experiments at —187° C. and 17° C. The experimental temperature factor comes out to be that given by Waller's formula for zero point energy. The average amplitude of thermal vibration is found to be 0.11 Ångström at —187° C. and 0.17 Ångström at 17° C. Since aluminum is a conductor of electricity it is assumed that the crystal consists of free electrons and a lattice of ionized atoms. It was found unnecessary to take account of the free electrons in calculating the theoretical F values based on the Schrödinger distribution of the electrons in the atom. However, the theoretical F values for the ions Al^{+1}, Al^{+2}, and Al^{+3} were found to give curves which agreed within experimental error with the experimental F curve

and hence no determination of the state of ionization of the aluminum atoms was possible. The U curve for Al^{+2} shows humps at about 0.05 and 0.25 Ångström from the center of the atom.

The Schrödinger models for Na^{+}, K^{+}, Al^{+2}, and Cl^{-}, which give F values agreeing with the experimental F values, all contain 2 K electrons and 8 L electrons. K and L electrons on the Schrödinger theory are electrons which are most probably at distances from the center of the atom respectively equal to the abscissæ of the first and second humps of a U curve.

The results reported in this section are collected in Table II.

TABLE II

Crystal	Atom	Average amplitude of thermal vibrations (Ångströms)			Most probable distances of electrons from center of atom (Ångströms)		
		—187°C.	17°C.	627°C.	K	L	M
Rocksalt	Na+		0.23	0.58	0.05	0.33	
	Cl—		0.20	0.58	0.04	0.18	0.85
Sylvine	K+	0.15	0.26		0.04	0.15	0.62
	Cl—	0.15	0.26		0.04	0.17	0.78
Aluminum	Al^{+2}	0.11	0.17		0.05	0.25	

From Eqs. (2), (7), and (11), it is seen that the atomic structure factor is a function of $\sin\theta/\lambda$. Since $n\lambda = 2d\sin\theta$ we see that the F values for a given crystal are a function of the order of reflection alone and are not a function of the wave length. Hence all F curves plotted against $\sin\theta/\lambda$ for rocksalt should be the same for different wave lengths reflected from the crystal. So far as rocksalt is concerned, W. L. Bragg, James and others have used both Rh Kα and Mo Kα X-rays and no difference in the F curves as plotted against $\sin\theta/\lambda$ has appeared. However, Miss Armstrong (24) reflected Mo Kα and Cu Kα rays from copper and iron powders. The F values for the Cu Kα rays reflected in a given order from copper were less than the F values for Mo Kα rays reflected in the same order. A similar result but with less difference between corresponding F values was found for the rays reflected from iron. It should be mentioned that while both the Mo Kα and Cu Kα rays excite the K spectrum of iron, it is only the Mo Kα rays which excite the K spectrum of copper. It seems then that F is a function of $\sin\theta/\lambda$ alone only so long as the X-rays used are not near a critical absorption wave length of the crystal.

Miss Armstrong (25), using the powdered crystal method, subjected diamond to X-ray analysis. She found a (222) reflection (this notation means a second order reflection from the (111) planes) from diamond. This reflection should not appear if diamond has exactly the structure usually assigned to it and consists of carbon atoms which are all alike. According to Miss Armstrong, this reflection might occur if the carbon atoms are of two kinds with different F values, or if adjacent carbon atoms shared electrons between them in such a way as to provide scattering centers on the line joining them. It seems, however, that neither explanation is entirely compatible with the experimental results.

It has long been felt that the F values for a crystal of a magnetic substance should change when the crystal is magnetized. Stearns (26), using a sensitive null method, in which two crystals and two ionization chambers were employed, was unable to detect any change in intensity when one crystal was magnetized, and hence found no change in the F values. The lack of change

in the F values means that the electron structure of an atom of a magnetic crystal is unchanged when the crystal is magnetized. It appears from this experiment that the ultimate magnet must be the spinning electron.

Wyckoff (27), in discussing Miss Armstrong's finding (24) that F is not a function of $\sin\theta/\lambda$ alone for a given crystal, points out that her conclusions are dependent upon the correctness of the measured absorption coefficients, since, as in Eq. (12), the calculation of the F values from the experimental intensities involves a knowledge of the absorption coefficient of the X-rays in the crystal. Accordingly Wyckoff used a crystal of NiO so as to avoid such an uncertainty, since the F values of two kinds of atoms in the same crystal can be obtained. The F curves for the oxygen atoms in the crystal when plotted against $\sin\theta/\lambda$ were found to be very nearly identical for the three wave lengths of Mo, Cu, and Ni Kα X-rays. On the other hand, relatively large differences were found to exist in the F curves for the nickel atoms. The variation in the F curves is thus a real effect and is not due to the use of an incorrect value of the absorption coefficient.

7. CONCLUDING REMARKS

Before bringing this paper to a close, it should be mentioned that a few years ago, before Schrödinger's wave mechanics had been applied to the problem of the reflection of X-rays from crystals, it seemed that some account should be taken of the Compton effect. Up till that time it had been impossible to construct Bohr models of the sodium or chlorine atoms which would give F values in agreement with the experimental F values for rocksalt. Williams (28) and Jauncey (29) used Bohr models for the atoms of the crystal and by modifying the theory so as to take account of the Compton effect were able to arrive at theoretical F values which agreed better with the experimental F values than had the previous theoretical F values. In the Compton effect, when X-rays of a given wave length are scattered, two lines appear in the spectrum of the scattered rays—one line, called the unmodified line, having the same wave length as that of the primary rays, and the second line, called the modified line, having a longer wave length than the primary rays. The X-rays which constitute the modified rays are not coherent with the primary rays and hence cannot take part in interference phenomena, of which reflection of X-rays from crystals is an example. However, Waller (30), Wentzel (31), and Waller and Hartree (32) have shown on the basis of wave mechanics that the coherent scattering by an atom may be calculated from its Schrödinger electron distribution by supposing the electron in this distribution to scatter according to the classical theory and then taking into account the interference between X-rays scattered from different parts of the atom. Since James, Waller, and Hartree have been able to devise Schrödinger atoms which give F values in agreement with the experimental values, it seems that the Compton effect does not need to be taken into account when such models of the atoms of a crystal are used.

In closing, it may be stated that the evidence obtained from experiments on the intensity of reflected X-rays from crystals strongly supports the Schrödinger theory of the electron distribution in the atoms of crystals.

REFERENCES

(1) COMPTON, ARTHUR H.: Physical Rev., January, 1917, IX, 29.
(2) SCHRÖDINGER, E.: Ann. d. Physik, 1926, LXXIX, 361.
(3) DEBYE, P.: Ann. d. Physik, 1914, XLIII, 49.
(4) BRAGG, W. LAWRENCE, JAMES, R. W., and BOSANQUET, C. H.: London, Edinburgh and Dublin Phil. Mag., March, 1921, XLI, 309.

(5) DARWIN, C. G.: London, Edinburgh and Dublin Phil. Mag., 1914, XXVII, Part I, February, p. 315; Part II, April, p. 675.
(6) BRAGG, W. H., and W. L.: X-rays and Crystal Structure. 4th Ed., G. Bell and Sons, London, p. 214.
(7) HAVIGHURST, R. J.: Physical Rev., January, 1927, XXIX, 1.
(8) BEARDEN, J. A.: Physical Rev., January, 1927, XXIX, 20.
(9) DUANE, WILLIAM: Proc. Nat. Acad. Sci., 1925, II, 502.
(10) COMPTON, A. H.: X-rays and Electrons. Chapter V. Van Nostrand & Co., New York.
(11) WALLER, IVAR: Upsala Dissertation, 1925.
(12) BRAGG, W. H.: London, Edinburgh and Dublin Phil. Mag., May, 1914, XXVII, 881. (W. L. BRAGG quoted in paper.)
(13) BACKHURST, IVOR: Proc. Roy. Soc. Lond., Series A, December, 1922, CII, 340.
(14) COLLINS, E. H.: Physical Rev., August, 1924, XXIV, 152.
(15) JAMES, R. W.: London, Edinburgh and Dublin Phil. Mag., March, 1925, XLIX, 585.
(16) Idem: Manchester Memoirs, 1926-27, LXXI, 7.
(17) JAMES, R. W., and FIRTH, ELSIE M.: Proc. Roy. Soc. Lond., Series A, December, 1927, CXVII, 62.
(18) JAUNCEY, G. E. M.: Physical Rev., November, 1922, XX, 405.
Idem: Physical Rev., November, 1922, XX, 421.
(19) THOMSON, J. J.: Conduction of Electricity through Gases. 2nd Ed., Cambridge University Press, p. 325.
(20) BARKLA, C. G., and AYRES, T.: London, Edinburgh and Dublin Phil. Mag., February, 1911, XXI, 270.
(21) JAMES, R. W., WALLER, IVAR, and HARTREE, D. R.: Proc. Roy. Soc. Lond., Series A, March, 1928, CXVIII, 334.
(22) JAMES, R. W., and BRINDLEY, G. W.: Proc. Roy. Soc. Lond., Series A, November, 1928, CXXI, 155.
(23) JAMES, R. W., BRINDLEY, G. W., and WOOD, R. G.: Proc. Roy. Soc. Lond., Series A, October, 1929, CXXV, 401.
(24) ARMSTRONG, ALICE H.: Physical Rev., Sept. 15, 1929, XXXIV, 931.
(25) Idem: Physical Rev., Oct. 15, 1929, XXXIV, 1115.
(26) STEARNS, J. C.: Physical Rev., Jan. 1, 1930, XXXV, 1.
(27) WYCKOFF, RALPH W. G.: Physical Rev., March 15, 1930, XXXV, 583.
(28) WILLIAMS, E. J.: London, Edinburgh and Dublin Phil. Mag., September, 1926, II (Ser. 7), 657.
(29) JAUNCEY, G. E. M.: Physical Rev., June, 1927, XXIX, 757.
(30) WALLER, IVAR: London, Edinburgh and Dublin Phil. Mag., November, 1927, IV (Ser. 7), 1228 (supplement).
(31) WENTZEL, GREGOR: Ztschr. f. Physik, 1927, XLIII, Part I, p. 1; Part II, p. 779.
(32) WALLER, IVAR, and HARTREE, D. R.: Proc. Roy. Soc. Lond., Series A, May, 1929, CXXIV, 119.

WHEN HAS VISCEROPTOSIS CLINICAL SIGNIFICANCE?[1]

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THIS paper is based on a study of hospital- and out-patients sent to the Department of Roentgenology for a diagnosis of gastro-intestinal pathology. Twenty per cent of the patients examined have clinical visceroptosis. The responsibility for the diagnosis rests upon the roentgenologist.

Visceroptosis has undoubtedly occurred since man assumed the upright position. In 1833 Glénard published his thesis on this subject, since which time visceroptosis has been called "Glénard's disease." It has been defined as a prolapse or falling or dropping of the viscera. When it involves the stomach it is termed "gastroptosis"; the intestines, "enteroptosis"; the colon, "coloptosis"; the liver, "hepatoptosis," and the kidneys, "nephroptosis."

The subject of visceroptosis has been studied for many years, but it is only since the discovery of the X-ray and the use of the opaque meal that exact observations have been made. At the present time there is much difference of opinion as to the degree of prolapse which is to be regarded as pathologic. Only the two most common manifestations of visceroptosis, namely, gastroptosis and coloptosis, will be considered in this paper.

It should be emphasized that there is a marked difference between anatomic and clinical visceroptosis. In the former, the low position of the stomach or colon does not interfere with physiologic function; whereas, in the latter the dropped or prolapsed position of the organ results in a perversion of physiologic function which gives rise to symptoms. Therefore, visceroptosis should not be viewed from the anatomic viewpoint. When clinical symptoms arise as a result of physiologic malfunction in a visceroptotic individual in whom organic disease has been excluded, then, and then only, has visceroptosis clinical significance.

Gastroptosis, often called *falling* or *dropping of the stomach,* results from a relaxation or a stretching of the mesenteric or peritoneal attachments. Clinical gastroptosis often follows where there has been emaciation and relaxation of the abdominal muscles, as well as absorption of fat from the lesser omentum and the gastrohepatic and gastrocolic ligaments. Gastroptosis is almost always acquired; some individuals inherit a constitutional predisposition toward it. The condition is more prevalent in the female, the ratio in our series being 4 to 1. The condition occurs in individuals from 20 to 70 years of age; 80 per cent of cases occur in the age period from 20 to 50.

In clinical gastroptosis the stomach is usually elongated, the greater curvature being considerably below the inter-iliac line, often resting on the pelvic floor. There is often an associated atony. The cardiac portion of the stomach is never displaced downward, whereas the pyloric portion often occupies a level below the normal. The most common position of the lowest part of the greater curvature in normal individuals, examined in the erect posture, was in the zone from 2 to 7 centimeters below the inter-iliac line. The average position of the lowest part of the lesser curvature was between the inter-iliac line and a point 5 centimeters above it, the pylorus being between 2.5 and 5 centimeters above the line. In individuals with the clinical type of gastroptosis, the average distance of the greater curvature below the inter-iliac line was 9 centimeters, whereas the average distance of the pylorus above the line was 2.9 centimeters. It is obvious that, anatomically, the two types of

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individuals show only slight variation. It is important to emphasize that the presence and the severity of the symptoms depend on the perversion of function of the organ or organs involved and not upon their position.

Coloptosis, or so-called *dropping* or *prolapse of the colon*, is likewise a result of relaxation of the ligaments which normally hold the colon in place. There is often a failure or atony of the abdominal musculature maintaining intra-abdominal tension. Coloptosis is usually right-sided. The region of the hepatic flexure, as well as the transverse portion, usually reveals sagging. Very often there is a dropping of the central portion of the transverse colon as far as the pelvic floor.

In the writer's series of 100 cases of clinical gastroptosis and coloptosis in which organic disease was excluded, the following conditions in respect to frequency were the predisposing causes: pregnancy, influenza, tuberculosis, colitis, pneumonia, pyelitis, thyrotoxicosis, and syphilis. As a result of the above conditions there was a loss of fat, relaxation of the ligaments as well as faulty tone of the abdominal muscles, associated with decreased intra-abdominal pressure.

The cardinal symptoms of clinical gastroptosis are pain or distress or a drag in the epigastrium, which occurs usually immediately after eating, when the patient is in the upright position. This was present in 95 per cent of the cases, nausea in 43 per cent, vomiting in 42 per cent, loss of weight in 39 per cent, and gas in 33 per cent. There was relief of symptoms in all cases when the patient was kept in the Trendelenburg position. The cardinal symptoms of coloptosis are distress or drag or a pain, more particularly at the sites of the splenic and hepatic flexures; very often soreness or pain at the region of the cecum. These symptoms are usually manifest when the patient is in the upright position, with relief of symptoms when the patient is in the Trendelenburg position.

Symptoms of lesser frequency in gastroptosis and coloptosis are migraine, vertigo, backache, fever, exhaustion, dyspnea, and particularly neurasthenia. The symptoms are due to a drag on the mesentery, with its resultant irritation to the sympathetics and vagus, and to duodenal stasis causing toxic absorption.

The responsibility for the diagnosis of clinical gastroptosis and coloptosis is almost entirely dependent upon the roentgenologist, as a careful objective exclusion diagnosis of organic disease of the gastro-intestinal tract must be made. The diagnosis of this condition is purely a fluoroscopic procedure. With the patient in the upright position behind the fluoroscopic screen, the stomach filled with the barium meal, he manifests the symptoms of which complaint is usually made. The cardinal diagnostic sign is that the symptoms are usually relieved when the stomach is elevated manually, and almost immediately entirely relieved when the patient is placed in the Trendelenburg position, using a tilt table. The symptoms recur when the patient is placed in the upright position and again disappear when he is placed in the Trendelenburg position.

Organic disease must be excluded. The heart and lungs are examined fluoroscopically and radiographically; the stomach, duodenum, jejunum, ileum, colon, pancreas and the appendix are excluded fluoroscopically; the genito-urinary and biliary tracts are excluded radiographically, when indicated.

It is important to bear in mind that organic disease is occasionally associated with clinical visceroptosis, and, when present, it is essential that both conditions be properly evaluated in order to obtain the best clinical results. Fifty-one per cent of the patients studied have had previous abdominal operations, many with no relief of their symp-

toms because the visceroptosis was disregarded in the therapy.

CONCLUSIONS

1. When symptoms arise as a result of perverted function in a visceroptotic individual in whom organic disease has been excluded, then, and then only, has visceroptosis clinical significance.

2. The cardinal diagnostic fluoroscopic sign of gastroptosis and coloptosis is that the symptoms are usually relieved when the stomach or colon is elevated manually, and almost immediately entirely relieved when the patient is placed in the Trendelenburg position.

3. The anatomical position of the stomach and colon in the so-called normal individual is dependent upon the habitus as well as the inherited constitutional frame of the individual. Their low position is of no significance except when it interferes with physiological function.

4. The responsibility for the diagnosis of clinical gastroptosis and coloptosis is almost entirely dependent upon the clinical roentgenologist, as a careful objective exclusion diagnosis of organic disease of the gastro-intestinal tract must be made.

DISCUSSION

DR. ROBERT SHOEMAKER (Philadelphia): I have been very much impressed by Dr. Beilin's paper, because it has been my own experience that the clinical men and the surgeons have shown apathy to visceroptosis. I have gone over about 140 cases of this condition at the Lankenau Hospital in Philadelphia and have been much struck by the diversity of the patients' complaints. This series represents cases in which definite organic disease had been excluded so far as possible. A catalogue of the patients' chief complaints looks like an exhaustive list of symptoms occurring in every type of visceral disease—peptic ulcer, cholecystitis, appendicitis, cystitis, renal calculus, and so on. The majority of these patients had consulted several physicians and had received a variety of diagnoses. Obviously, they had not obtained relief. The X-ray findings were perfectly definite and the real problem consisted in demonstrating or excluding true organic disease. Our treatment was directed primarily toward the correction of the ptosis, and for this an external mechanical support was found to be indispensable in the great majority of cases. Systematic checking-up of supports by fluoroscope revealed the fact that the ordinary corset-type or surgical belt was of no use whatever for patients with a flat or a scaphoid abdomen. The iliac crests received the pressure and the ptosed colon, for example, reposed on the bladder and uterus just as it did before. We were obliged to have recourse to a specially constructed apparatus for this type of abdomen, and repeated fittings under fluoroscopic control were often required before the ptosis could be overcome. The rest of the treatment comprised general hygiene, regulation of diet, the exhibition of a few well-chosen drugs, and, last, but not least, a systematic follow-up of patients. The results obtained were often spectacular and nearly always encouraging. A patient that has had a ptosis of long-standing, and has been adequately relieved, is one of the most grateful persons you can meet.

DR. BEILIN (closing): There are a few points I wish to emphasize. The important aspect of my paper is the fluoroscopic diagnostic sign in this condition, which is overlooked to a tremendous extent. That is, these individuals manifest their symptoms on a full stomach when in the upright position. Their symptoms are immediately relieved when the abdominal wall is elevated manually and when the patient is placed in

the Trendelenburg position. The proof of the correctness of the diagnosis is based upon the therapeutic test. Dr. Anders Frick, of Chicago, has made a study of these cases for twenty years, a large number of which have been permanently cured.

The Radioscopical Diagnosis of Filariasis. J. B. Christopherson. Brit. Med. Jour., May 4, 1929, No. 3,565, p. 808.

The X-ray offers a simple and reliable method of diagnosis of filariasis. Filariasis is due to the trematode worm, *Filariasis bancrofti,* which in its adult and larval stages infests the human lymphatics, is a widespread infection in many tropical countries, and is transmitted by three genera of mosquitos—culex, aedes, and anopheles. The only previous means of diagnosis before the onset of elephantiasis was by blood examination for eosinophilia and the presence of larvæ. If, however, the blood examination is negative, as often happens in mild cases where the parent worms are dead, calcified, and encysted, the diagnosis, without the help of the X-ray, is a matter of opinion.

The cyst may be present in any of the skeletal muscles, including the facial muscles. These cysts throw a shadow about half an inch long, thicker at one end, tapering to the other, and the broad end casting a less dense shadow than the tapered end.

WALLACE D. MACKENZIE, M.D.

THE CALIBRATION OF THE "FINGERHUT" IONIZATION CHAMBER[1]

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A PROBLEM of fundamental importance in the standardization of X-ray dosage is the comparison of the Roentgen units established independently in the several national and local laboratories. It is ordinarily not possible or, perhaps, desirable to have every standardization equipment identical, and consequently any medium for intercalibrating the standards must be capable of being standardized accurately and unambiguously against each standard. Up to the present[2] the only international comparison of X-ray standards has been through the use of the "Fingerhutkammer,"[3] when Behnken carried such a calibrated chamber to several laboratories, measuring the Roentgen unit as determined by each. The discrepancies in the calibrations against the respective standards were then used as correction factors when necessary.

The next problem of practical value is the calibration of the small portable ionization chamber or dosage meter. Since biological reactions are seldom reproducible to within a small percentage, an accuracy of about 4 per cent is usually sufficient for the calibration of a dosage meter which is to be used for medical purposes. If a similar instrument is to be used for comparing standards, the accuracy of calibration should then be 0.5 per cent or better.

In some preliminary investigations it was found, however, that to attain an accuracy of 1.0 per cent in calibrating a small ionization chamber considerable care was necessary, and, moreover, that differences up to several per cent might easily arise, due to differences in the technic used by different investigators. Consequently, a study was made of certain details in the methods for calibrating the thimble ionization chamber and of the probable sources of error involved. For most of the errors it is not deemed necessary to make corrections, inasmuch as special technic permits them to be avoided. We will point out the sources and magnitude in the case of several of the errors, without attempting to provide corrections except in method.

In two earlier papers[4] [5] several possible sources of error in the standard ionization chamber were indicated, and it was suggested that they were of such a nature as to admit of the possibility of counterbalancing each other. The magnitude of some of them was determined and the experimental arrangements of several other observers were analyzed for the presence of such errors, which were, in general, found to be small. In the present work it has been found that the errors are not so likely to counterbalance each other, but tend rather in the same direction; that is, they are such that the thimble chamber measures too little ionization.

In this study the standard ionization chamber of the Bureau of Standards was used as a reference for all measurements. A number of different types of dosage meter were available,[6] of which two were chosen as being representative of all those employing the more commonly used thimble cham-

[1] This is Research Paper No. 169. Reprinted by permission from the *Bureau of Standards Journal of Research*, May, 1930, IV.

[2] Behnken, Hermann: Strahlentherapie, 1928, XXIX, 192.

[3] The more common designation of the small chambers used in connection with dosage meters is the original German term, "Fingerhutkammer." In the future we shall use the term "thimble chamber" for this device.

[4] Taylor, L. S.: Bureau of Standards Jour. Research (Research Paper No. 56), 1929, II, 771.

[5] Taylor, L. S.: Bureau of Standards Jour. Research (Research Paper No. 119), 1929, III, 803.

[6] Other dosage meters available were of the following types: Furstenau, Müller, Küstner "Eichstandgerat," Solomon, and Wulf. Of these, the Furstenau and Küstner instruments do not involve the use of a "Fingerhutkammer."

ber. Consequently, our study was confined to the Friedrich and the Glasser chambers, each, however, being used in conjunction with the same string electrometer.

an area necessary for the standard, it does not necessarily satisfy the requirements of the small chamber except at comparatively great distances from the tube. On the other hand, if the beam uniformity is made to satisfy the small chamber by, say, enlarging the limiting diaphragm next to the tube, then an error may be introduced in the standard determination due to off-focus radiation. It is evident then that the two measurements must be carefully made with proper regard to these conditions if an accurate calibration is to result.

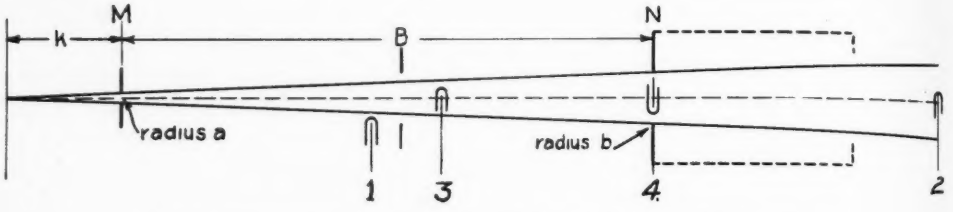

Fig. 1. Arrangement of diaphragms and thimble chambers for calibration.

II. ENERGY DISTRIBUTION ACROSS SECTIONS OF THE STANDARD X-RAY BEAM

The most important requirement for the standard X-ray beam is that it be uniform over the entrant diaphragm of the standard ionization chamber.[7 8 9 10] Beam uniformity over the area of the thimble chamber is likewise the outstanding requirement in the comparison against the standard. Below are given a number of curves showing the energy distribution over a section of the X-ray beam, illustrating correct and incorrect conditions.

The presence of the limiting diaphragm near the tube complicates matters somewhat. It has been found, however, that for standard ionization chamber measurements such a diaphragm near the tube has certain advantages in avoiding the effect of off focus[11] and stem radiation, although its use necessarily makes the uniform area of the beam small. As a consequence, if we have a thimble chamber whose length is from 1.5 to 4 cm., it is clearly possible that, while the X-ray beam may be sufficiently uniform over

In calibrating a small chamber the various methods used may be reduced to four, as indicated diagrammatically in Figure 1. The first[12] (Position 1) places the thimble chamber between the X-ray tube and standard ionization chamber *N*, and sufficiently off the axis of the X-ray beam so that it does not intercept the part of the beam entering the standard chamber. The ionization currents are then measured simultaneously and the inverse square law applied to the two. This is the system used by Behnken and, as seen, assumes that the beam is uniform over a comparatively wide area. In the second method (Position 2) the thimble chamber is beyond the standard and on the same axis; the readings are made simultaneously and the inverse square law applied. The third (Position 3) involves a substitution method, the thimble chamber being inserted between the tube and the standard on the axis of

7Taylor, L. S.: See Footnote 5.

8Mayenord, W. V.: Brit. Jour. Radiol., I, 125.

9Glasser, Otto, and Portmann, U. V.: Am. Jour. Roentgenol. and Rad. Ther., 1928, XIX, 47.

10Behnken, Hermann: Strahlentherapie, 1927, XXVI, 79.

11Off-focus radiation is defined as that radiation from an X-ray tube which originates from points on the target face other than the sharply defined focus.

12Behnken, Hermann: See Footnote 10.

the beam which is utilized by the standard; the readings are taken separately and the inverse square law applied. The fourth (Position 4) also involves a substitution since an extremely steady X-ray equipment, controlled by a specially constructed voltage stabilizer, is available. In this equipment the standard and small chambers are fixed

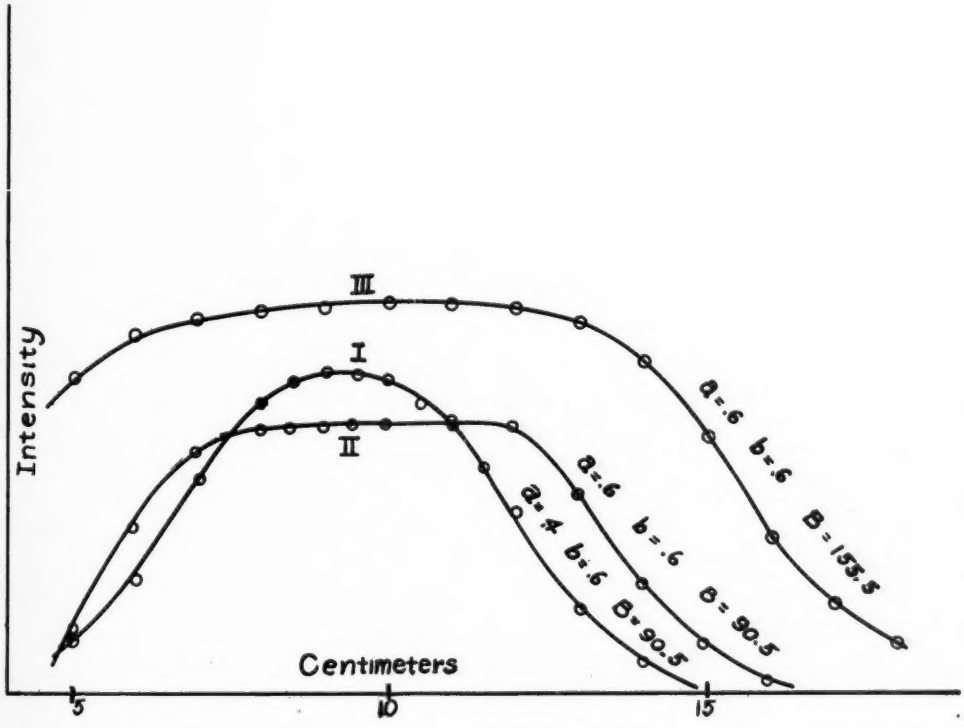

Fig. 2. Intensity distribution across standard X-ray beam (measured with standard chamber).

method,[13] the thimble chamber being inserted in the position occupied by the front diaphragm of the standard and the use of the inverse square law thus avoided—a very desirable feature. The first two methods have the advantage of simultaneous measurement, thus minimizing the effects of an unsteady source of radiation. The choice of any of the methods will depend upon the beam uniformity, which in turn depends on the limiting diaphragm M and the applicability of the inverse square law. The last method is used by the Bureau of Standards, in position, while the X-ray tube and beam are shifted laterally from one to the other, keeping the relative position of target to chamber the same for both.

The uniform distribution of energy across the beam may be tested most easily by means of an ionization chamber. Photographic determinations are more accurate if carefully executed, inasmuch as there is no effective slit width for which allowance must be made. Figure 2 shows for several diaphragm combinations and distances from the X-ray tube, the intensity of ionization measured by the standard chamber as the

[13] Glasser, Otto, and Portmann, U. V.: See Footnote 9.

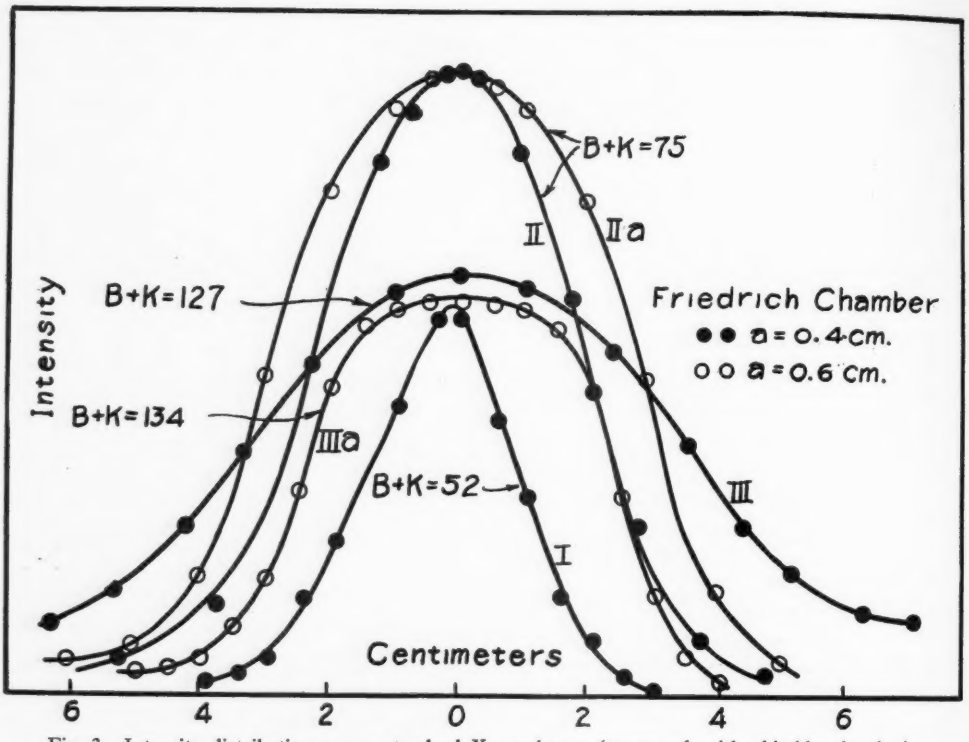

Fig. 3. Intensity distribution across standard X-ray beam (measured with thimble chamber).

beam is moved laterally across the entrant diaphragm *N*. (The curves are plotted on different scales so that the relative ordinates are without significance.) For all of this study the focal spot had a radius of about 0.6 cm. and the diaphragm *M* likewise a radius of 0.6 cm. except where otherwise indicated. In Curves I and II the distance from tube to chamber was 90.5 cm., while the radii of the limiting diaphragm *M* were 0.4 and 0.6 cm., respectively. In Curves II and III, both diaphragms had 0.6 cm. radii and the distances were 90.5 and 155.5 cm., respectively. It will be noticed that under the conditions of Curve I the peak of the curve is relatively narrow; hence, proper alignment of the system is very necessary, so that, if possible, such conditions are avoided. By increasing the size of diaphragm *M* to a radius of 0.6 cm. (Curve II) the peak is considerably broadened. though it is not of uniform intensity over its width. However, the increase in *M* may be undesirable in that it allows "off-focus" radiation to enter the standard chamber. Curve III is similar to II except that it has a broader peak. It is also of interest to note that all curves are very nearly symmetrical. This indicates a correct adjustment of the limiting diaphragm *M*, since if *M* were out of alignment, off-focus radiation would show up as a dissymmetry. After correcting for the diameter of the large diaphragm, the measured width of the peaks agree fairly well with the calculated widths.

The calibration of a thimble ionization chamber placed in the X-ray beam under conditions corresponding to Curve I, would be in doubt if not in serious error, since the X-ray intensity would not be uniform over the length of the chamber. Placed in the beam corresponding to Curve II, the flux

density of the beam would be sufficiently uniform, but, due to the very large diaphragm *M* used in the standard system, an error due to off-focus radiation is introduced in the standard which rules out such an arrangement. A calibration of the fourth type, however, would be satisfactory under conditions corresponding to III, in that the beam is uniform over the length of the thimble chamber and at the same time off-focus radiation is excluded from the standard chamber.

If now, using a thimble ionization chamber (Friedrich in this case), we measure the energy distribution across the beam, the symmetry usually disappears and the width of the peak is apparently diminished. In general, any dissymmetry is due to the construction of the thimble chamber, which is such that the measured ionization is not uniform over its length. The apparent narrowness of the peak is caused by the large "effective slit width" of the Friedrich chamber, the actual uniform part of the beam being some 2 cm. greater in diameter.

Figure 3 gives a set of such energy distribution curves under several different sets of conditions, Curves I, II, and III being taken with a limiting diaphragm *M* of diameter 8 mm., and curves IIa and IIIa with a limiting diaphragm *M* of diameter 12 millimeters. With the standard chamber at the same relative positions as indicated for the thimble chamber and the diaphragm *M* having an 8 mm. diameter (first case), the off-focus radiation is definitely excluded, and an accurate standardization of the beam may be effected. With the diaphragm *M* having a 12 mm. diameter (second case), off-focus radiation enters the chamber and impairs the results.

III. THE INVERSE SQUARE LAW FOR THIMBLE CHAMBERS

In a paper referred to above[14] it was shown that, depending on whether the target, as viewed from the position of the chamber diaphragm, does or does not fill the aperture of the target diaphragm, the inverse square for computing intensity is applied, respectively, to the target diaphragm distance, or the target distance. Thus, when the ionization chamber diaphragm fills the aperture of the system,[15] the distance must be measured between the limiting diaphragm *M* and the chamber diaphragm *N*. This condition becomes more important when using large ionization chamber diaphragms.

Since to obtain sufficiently large effects, most thimble ionization chambers subtend a fairly large solid angle as measured from the focus, the inverse square law was investigated in a manner similar to that used for the standard chamber. The thimble chamber and electroscope tube were mounted so as to move along a track 2 m. long, placed parallel to the X-ray beam. The vertical and horizontal alignment was determined by measurement as above, the chamber being placed in the center of the uniform area of the beam. Ionization currents in the thimble chamber were measured for various settings of the chamber along the track, the position being measured with reference to the diaphragm *M*.

Plotting the intensity (I) against the square of the reciprocal distance ($1/B^2$), it is seen in Figure 4 that there is a distinct break in the curves. Three such curves are given: Curve G for a Glasser 1 cm.^{3} chamber, and Curve F for a Friedrich chamber, the first having an outside length of 2.9 cm. and the second an outside length of 2.7 centimeters. It will be seen also that the break in Curve G occurs at a position corresponding to a distance farther from the tube than the break in Curve F. Likewise the curves for both Friedrich and Glasser chambers break at a point farther from the

[14] Taylor, L. S.: See Footnote 5.

[15] The aperture of the system is defined as the solid angle subtended by the focal spot and the limiting diaphragm *M* (Fig. 1).

tube than a similar Curve S for the standard chamber. It is seen that the lower portion of each curve passes through the origin, indicating that the inverse square law is obeyed only beyond a certain distance from the X-ray tube. Also on the Curve G it is seen that the points 1, 2, and 3 are far off the straight portion covering smaller distances. This divergence is caused by approaching too closely to the tube where the beam intensity varies very rapidly across the diameter occupied by the chamber. (See Curve I, Fig. 3.)

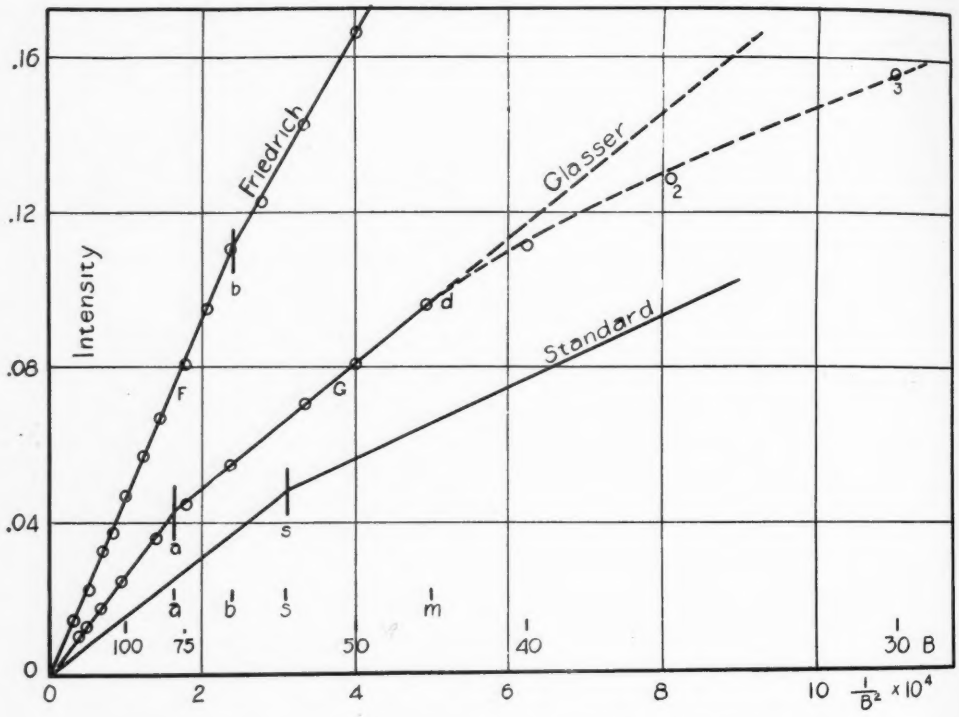

Fig. 4. Divergence from the inverse square law for three ionization chambers.

If we replot these same data as log I against log B, we may determine the exact divergence from the inverse square law. (Fig. 5.) If the inverse square law is obeyed, the points should lie along a straight line having a slope of −2.0. Actually it is seen that for a Friedrich chamber only the portion bF has a slope of approximately −2.00, for a Glasser chamber the portion aG, these points corresponding to distances far from the tube. If we plot log I against log $(B+k)$ for the Friedrich chamber, it is seen that the part $b'W$ most nearly approaches the slope −2 (being actually −2.04), corresponding to distances near to the tube. It is important to notice that the inverse square law is not obeyed exactly over any of the range of $(B+k)$. This bears out the conclusion drawn in an earlier paper[16] that the use of an extended source of radiation appears to be preferable for precise X-ray standardization.

By analogy to the case of the standard chamber, where now the thimble chamber

[16] Taylor, L. S.: See Footnote 5.

replaces the standard chamber diaphragm, we should expect a divergence from the inverse square law at the position where the focal spot, limiting diaphragm and standard chamber diaphragm (half the effective length of the small chamber in this study),

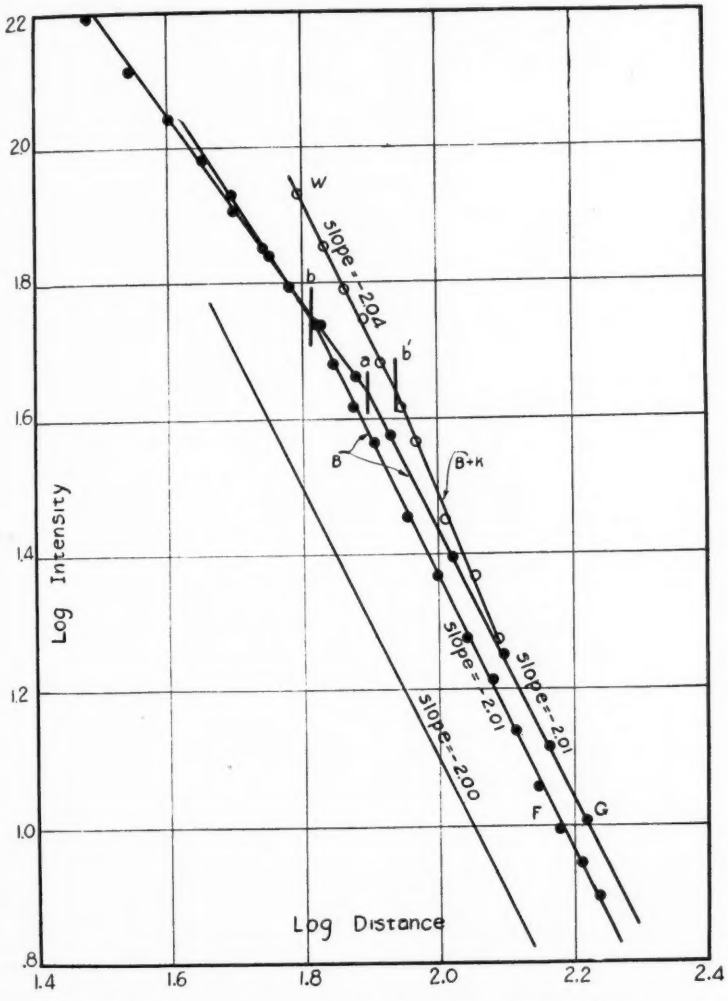

Fig. 5. Inverse power law for three ionization chambers.

thimble chamber no longer fills the aperture of the system.[17] This should be at such a distance that

$$f = \frac{ka + kb + aB}{B}$$

where f, a, and b are the respective radii of and B and k are as indicated in Figure 1. However, it is impossible to determine the effective length of the chamber accurately, hence, merely the order of magnitude of B can be calculated.

Having observed such a discontinuity in the intensity curve for the thimble chamber, we are confronted with the question of com-

[17] See Equation (7) and Fig. 1 (c) in Taylor, L. S.: Bureau of Standards Jour. Research (Research Paper No. 119), 1929, III, 803.

paring the ionization measurements of standard and thimble chambers. Curve "Standard" in Figure 4 is for the standard chamber when using the same limiting diaphragm *M* and an arbitrary standard chamber diaphragm *N*. It is seen that the break point for this curve differs from the first two.

Referring to Figure 5, we find that when the thimble chamber is used at such distances that the inverse square law is applied to the diaphragm *M*, the exponent of the distance is –2.01, thus differing from –2.00 by 0.5 per cent. On the other hand, for such distances that the inverse square law is applied to the target, the exponent is about –2.04, giving a difference of 2.0 per cent from –2.00. Correspondingly, we find when using a standard in place of a thimble chamber that the divergence of the respective exponents agrees in order of magnitude with the thimble chamber. Thus, if one chamber is calibrated against the other over regions where their exponents agree, the errors introduced will neutralize each other. However, if the calibration is made over regions where the two exponents differ, there will be an error of about 1.5 to 2.0 per cent. In other words, for calibration purposes, conditions should be so selected that either both chambers fill the aperture of the system or neither chamber fills it. Thus for the Glasser chamber the comparison should be made in the regions *O* to *a* or *s* to *m* and not in the region *a* to *s*. When calibrating dosage meters for medical uses the errors introduced as above may not be serious, whereas for standardizing purposes their magnitudes warrant proper consideration.

IV. DISTRIBUTION OF IONIZATION IN THIMBLE CHAMBERS

In studying the general behavior of a thimble chamber it is important to know the distribution of ionization in the chamber itself. (See Sec. II.) For instance, it was found when measuring the intensity distribution across the beam that the peak of the intensity curve did not always coincide with the position of the geometrical center of the particular chamber used to determine it. To check this the beam center was obtained accurately by means of a Glasser 1/20 cm.^{3} chamber and the geometrical center of the larger (1 cm.^{3}) chamber set at this point, after which it was usually found that the 1 cm.^{3} chamber had to be shifted slightly in order to obtain the maximum ionization reading. This means that we cannot rely upon the geometrical center as the true center point in aligning the chamber for calibration.

To measure the distribution of ionization in the thimble chamber (and likewise to obtain the effective center), the X-ray beam was defined by a long slit about 1 mm. wide and the chamber moved across this beam by small steps in a direction parallel to the chamber axis and at right-angles to the long axis of the slit, so that at any position only a small portion of the chamber air volume was ionized by the direct beam. Figures 6 and 7 show the distribution of ionization in a 1 cm.^{3} Glasser and a Friedrich chamber, respectively. Below each curve is a half-section scale drawing of the corresponding chamber. In the case of the Friedrich chamber the center of the ionization peak agrees fairly well with the geometrical center. However, due to the very uneven ionization at the ends it is difficult to predict the true effective center when used in a broad beam. There is a marked increase in the ionization at the end of *B* of the chamber, this being due to the metal collar which supports the chamber cap. The case of the 1 cm.^{3} Glasser chamber is similar, although the center of the ionization peak is farther from the geometrical center, while the scattering at the end *B* appears to be negligible.

As pointed out in Section II, it is not ordinarily possible to calculate the break point

in the inverse square law from the measured length of the thimble chamber; however, having found the break point we may attempt to calculate the effective length of the chamber by reversing the process. A comparison of the values given in Column

TABLE I

Chamber	Measured length (cm.)	Calculated length (cm.)	Experimental length (cm.)
Friedrich	2.7	2.5	2.0
Glasser	2.9	2.1	2.0

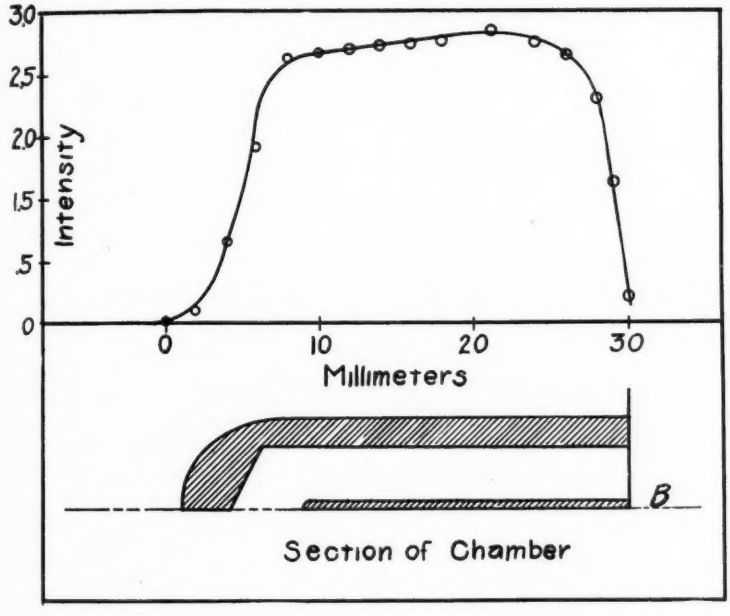

Fig. 6. Distribution of ionization along axis of Glasser chamber.

3 of Table I, obtained in this way, with the over-all geometrical length given in Column 2 shows at once the futility of trying to calculate the working range for standardization on the basis of the measured chamber length. The fact that the experimental length given in Column 4, obtained by measuring the width of the peaks in Figures 6 and 7, is the same for both the Friedrich and Glasser chambers would lead to the conclusion that the working range of the inverse square law was the same for both, and yet Figure 4 shows that their break points differ by 8 centimeters.

V. SATURATION CONDITIONS IN THIMBLE CHAMBERS

When a small ionization chamber is used with a medical-dosage meter the system is always charged to a potential of the order of 300 to 500 volts, thus assuring complete saturation of the chamber. In such cases the working sensitivity is comparatively low, requiring very long exposures for the radiation ordinarily used in treatment—an undesirable feature when using the small chamber for an intercomparison between two standards, since the likelihood of severe

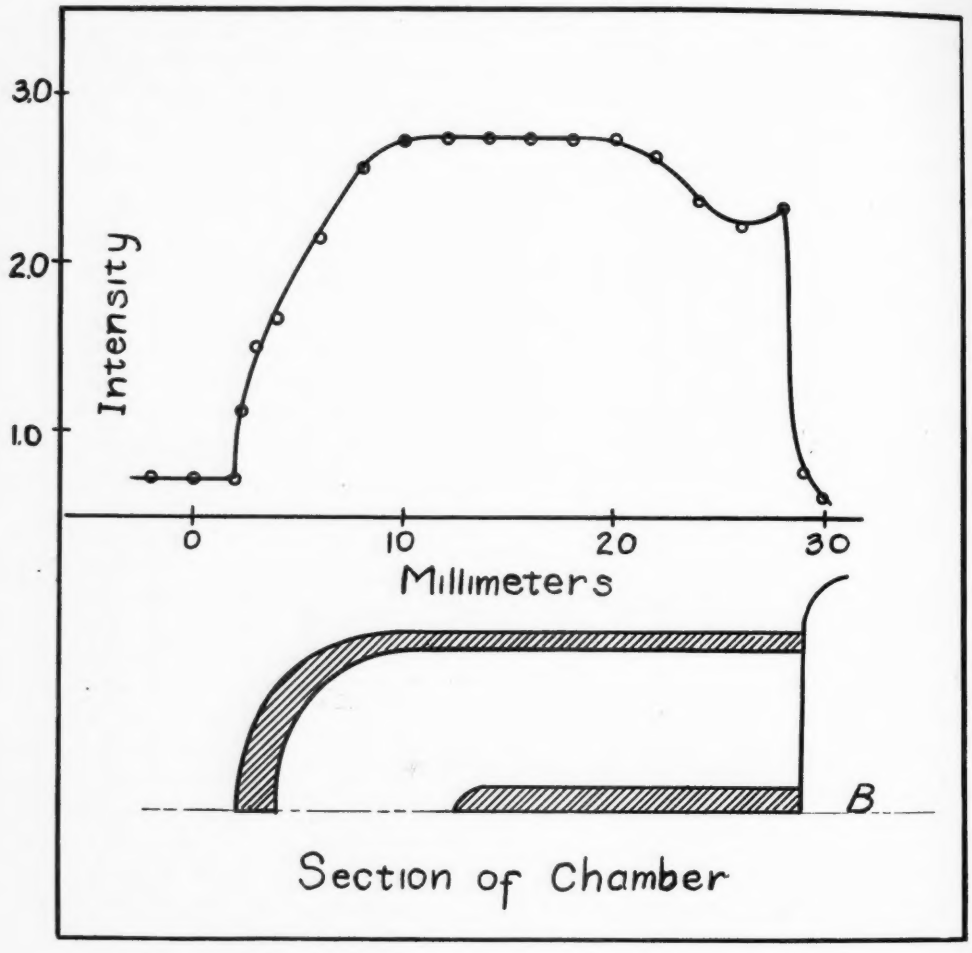

Fig. 7. Distribution of ionization along axis of Friedrich chamber.

fluctuations in beam intensity is greater for long-time intervals. As a consequence lower charging voltages (50 to 100) are frequently used, thus increasing the working sensitivity of the system.[18] It is questionable whether there is always complete saturation under such conditions.[19 20]

To test this a system was arranged so that a full-scale deflection of the electrometer corresponded to a potential of about 50 to 100 volts on the ionization chamber electrode. With the chamber exposed to a steady source of radiation, times of transit were measured for, say, every five divisions on the electrometer scale. Plotting time against the voltage corresponding to each scale reading a straight line would indicate uniformity of measured ionization; that is, saturation. It was found, however, that actually there was a slight curvature below

[18]The ionization current is proportional to the loss of potential of the system per unit time. The tension of the electrometer fiber is adjusted to give a full-scale deflection for any voltage used on the chamber, so that when exposed to the same radiation, for equal scale deflections the time is less, the lower the full-scale voltage on the system.

[19]Fricke, Hugo, and Glasser, Otto: Am. Jour. Roentgenol. and Rad. Ther., 1925, XIII, 453.

[20]Braun, R., and Küstner, H.: Strahlentherapie, 1929, XXXII, 550, 739.

about 50 volts for the particular chamber. The average ionization current over any interval is proportional to $\triangle V/\triangle t$, the voltage increment over the time interval. Thus, plotting $\triangle V/\triangle t$ against V we may obtain a saturation curve for the chamber in question. Such a curve for a Glasser chamber is shown in Figure 8. There is considerable error in obtaining such a curve, but the trend of the points indicates beyond any question that there is not complete saturation below 50 volts.

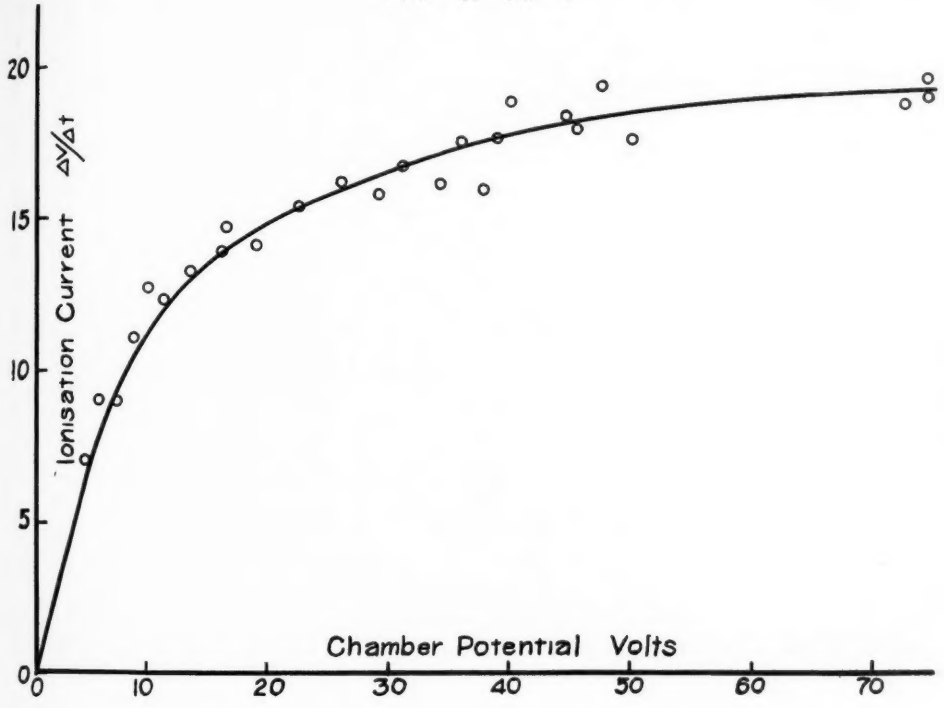

Fig. 8. Voltage saturation curve for thimble chamber.

VI. "WALL EFFECT" IN THIMBLE CHAMBERS

It has been well recognized that, for most small ionization chambers, the "wall effect" has a very decided influence upon the ionization measured.[21] [22] It was this effect which prompted Fricke and Glasser[23] to develop the "air wall" chamber in which the walls are made up of a compound having the same effective atomic number as air, and in which the ionization is closely parallel to that in an unrestricted volume of air. However, the extensive use of chambers having walls of graphite, magnesium, horn, celluloid, etc., which do not fulfill this condition, makes it necessary to establish some correction factor for the wall effects. Behnken[24] applies a correction determined by the half value layer in copper for each kind of radiation used. His method is probably sufficiently accurate and there seems little chance of improvement unless a standard source of X-rays in which there is a fixed energy distri-

[21] Glasser, Otto, and Portmann, U. V.: See Footnote 9.
[22] Behnken, Hermann: See Footnote 10.
[23] Fricke, Hugo, and Glasser, Otto: Am. Jour. Roentgenol. and Rad. Ther., 1925, XIII, 462.
[24] Behnken, Hermann: See Footnote 2.

bution is established. This might be approached by using constant potential on a tube of somewhat special but nevertheless simple construction. However, to introduce the X-ray tube being shifted from one system to the other between readings.

Observations may be made in two ways, depending upon the kind of X-ray equip-

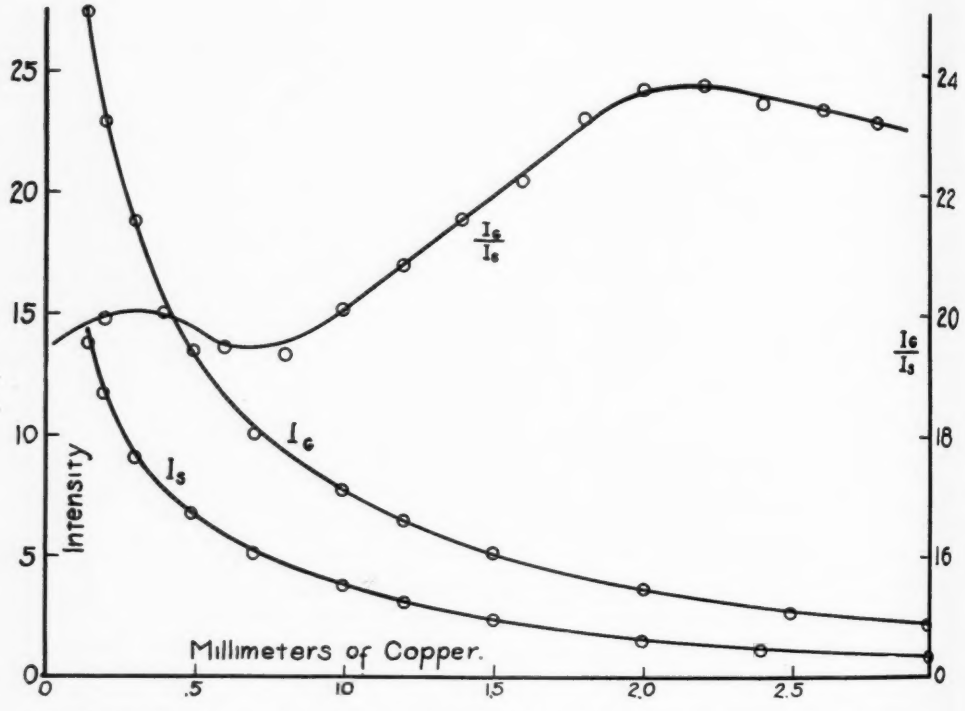

Fig. 9. Dependence of measured ionization in a thimble chamber as a function of filtration.

the further complication of a standard source of X-rays does not seem warranted at this time.

To show the deviation introduced by the wall effect comparisons were made against the standard chamber, as indicated in Figures 9 and 10. The Glasser chamber is made of graphite, while the Friedrich chamber is horn coated with graphite, these being representative of all of the small chambers available. They were each used with the same electroscope—a modification of the Lutz-Edelman, constructed at the Bureau of Standards. Readings were taken alternately with those of the standard chamber, ment and the control available. The first method is to maintain a given filter in the beam and vary the voltage, and the second is to maintain the voltage constant and change the filter. In both cases the ionization readings of the two chambers are compared.

Figure 9 shows two copper absorption curves made with the standard and the Glasser chambers, respectively, at a tube potential of about 160 K.V. On the same chart is shown the ratio I_g/I_s, obtained from the curves I_g and I_s. It is seen that this ratio varies from about 19.5 to 23.7, or about 9.5 per cent from the mean. If we could know

that at any point the ratio was correct, then a simple correction for the remaining points could be made. Practically, however, this is impossible. Again, for the same chamber the ting and reading the curves. The importance of the curves lies in showing the complete lack of parallelism in the ionization as measured by the two methods.

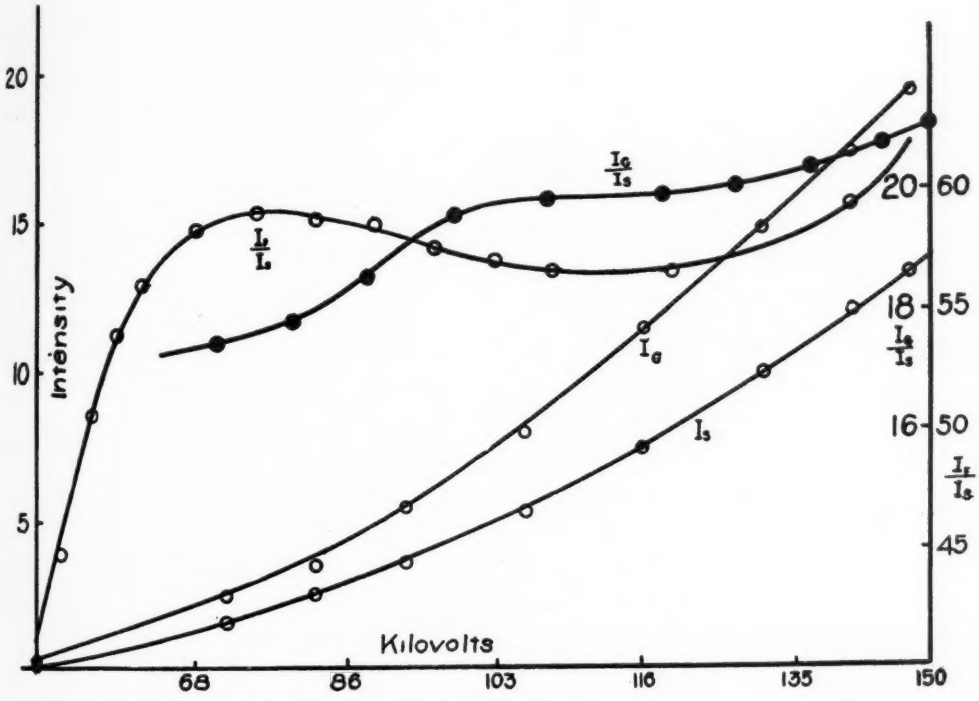

Fig. 10. Dependence of measured ionization in a thimble chamber as a function of voltage applied to X-ray tube.

filter was fixed at 0.6 mm. copper and the voltage varied over a wide range. Figure 10 gives the corresponding I_g and I_s curves and again the ratio I_g/I_s. In this case the ratio varies from 17 to 21, or about 10 per cent from a mean value. As would be expected in both cases, the greatest variation occurs at low voltages and small filtration, under which conditions there is a large amount of soft radiation in the beam. It should be pointed out that in the I_g/I_s curves there may be an error of 2 or 3 per cent, since the ratio is obtained from two sets of experimental data each having a small error, and since there may also be some error in plot-

In order to obtain some idea of the relation between the measured ionization in two different thimble chambers, Figure 10 also shows a curve of $I_f I_s$ for a Freidrich chamber under conditions identical with those for the Glasser chamber. It will be pointed out only that the form of the $I_f I_s$ curve is quite different, as might be expected from the differences in construction between the two chambers.

The most important result of the investigation has been to show the inadequacy of the thimble ionization chamber as a medium through which to compare the fundamental standards in various laboratories. An al-

ternative method has been under investigation for several months and will be described in detail at an early date.

VII. SUMMARY

As indicated in the body of the paper there are five factors which must be taken into consideration when calibrating a "Fingerhut," or thimble ionization chamber, against an accepted form of standard air ionization chamber. A summary of the possible errors follows:

1. That due to variable energy distribution across the standard X-ray beam. In general, a standard beam will have but a narrow region in its center where the intensity is nearly uniform. Improper placement of the thimble chamber in this beam tends to make the thimble chamber indicate too low X-ray intensity.

2. When the uniform area of the X-ray beam is too small to entirely cover the thimble chamber, too low X-ray intensity will, in general, be indicated by the ionization measured in the chamber.

3. Less than saturation voltage on the thimble chamber will also indicate too low intensity. (Saturation is usually assured in medical dosage meters, but not always in the case of standardization dosage meters.)

4. Improper application of the inverse square law applied in standardizing the thimble chamber will, in general, produce an error in the direction of measuring too low X-ray intensity.

5. The "wall effect" in any but the "Fricke-Glasser air wall chamber" may produce an error in either direction, depending upon the particular chamber used. In general, this effect is so pronounced that an accurate calibration is obtainable only under identical conditions regarding filtration, tube potential, and wave form of the generating equipment.

Some of these factors are of little importance when calibrating a dosage meter which is to be used only for medical purposes. However, if such a dosage meter is to be used for standardizing purposes or for comparing different standards, each factor must be carefully considered.

THE CRYSTAL STRUCTURES OF TRIMETHYL AND DIMETHYL ETHYL SULPHONIUM CHLOROSTANNATES AND OF METHYL TRIETHYL PHOSPHONIUM CHLOROSTANNATE

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DATA upon the structures of several substituted ammonium chlorostannates[1] have already been published. The present determinations continue these studies by replacing the substituted ammonium radicals with corresponding sulphonium and phosphonium groups.

All three of the crystals described in this paper appear to be optically isotropic and cubic in form. Although no previous crystallographic description of them could be found, the corresponding chloroplatinates[2] are reported to form optically isotropic octahedra or octahedra with small hexahedral faces. Only octahedral faces were found on any of the crystals, but Laue photographs of the trimethyl and dimethyl ethyl sulphonium chlorostannates taken normal to (111) show plainly the hemihedry characteristic of Ti (T^h) or T. Although these sulphonium salts crystallized readily, producing clear, well-formed octahedra of fair size, single crystals of methyl triethyl phosphonium chlorostannate large enough for Laue or oscillation photographs were not obtained.

The preparation of each chlorostannate was effected by neutralizing the appropriate substituted phosphonium or sulphonium hydroxide with HCl and adding an aqueous solution of H_2SnCl_6. These hydroxides were made by R. E. Marker of this Institute.

The crystal structures were determined in the usual fashion from Laue, oscillation spectral and powder photographs.

THE CRYSTAL STRUCTURE OF TRIMETHYL SULPHONIUM CHLOROSTANNATE

The data for this study were obtained from Laue photographs and from oscillation photographs using both copper and molybdenum radiation.

Six comparison photographs were made between the (111) face of $[(CH_3)_3S]_2SnCl_6$ and the (001) face[3] of β—Al_2O_3 (d_{001}= 11.24 Å.) using copper radiation. The average of eighteen reflections taken from the first, second, and third orders on these photographs gives d_{111}= 7.17 Å., which leads to the length of a cube edge a_o=12.41 Å. The density as obtained by the ordinary suspension method is $\rho_{20°}$= 1.69. Calculation from this density shows that a unit cube having the foregoing a_o will contain four molecules (m = 4.03). Data from an oscillation spectral photograph using molybdenum radiation are reproduced in Table I. Typical results on an octahedral Laue photograph are listed in Table II. Although the strongest first order reflections have only odd indices, such reflections occur from all sorts of planes so that the fundamental lattice is Γ_c. Of the possible first order spots with one index zero those are found which are (0, even, odd), whereas those that are (0, odd, even) and (0, odd, odd) are invariably absent. This is the distinguishing criterion of Ti-6 (T_h^6), which, therefore, is

[1] Wyckoff, R. W. G., Am. Jour. Sci., 1928, XVI, 349.
Idem, Ztschr. Kristallographie, 1928, LXVIII, 231.
Wyckoff, R. W. G., and Corey, R. B., Am. Jour. Sci., 1929, XVII, 239.
Idem, Am. Jour. Sci., 1929, XVIII, 138, 437.

[2] See Groth, Paul, Chemische Krystallographie, Leipzig, 1906, I, 479, 482.

[3] Pauling, Linus, and Björkeson, Albert, Proc. Nat. Acad. Sci., 1925, XI, 445.

TABLE I

TYPICAL REFLECTION SPECTRAL DATA UPON PHOTOGRAPHS OF TRIMETHYL SULPHONIUM CHLOROSTANNATE

[(111) as Principal Spectrum]

Indices	Intensity	Indices	Intensity
111	v.s	220	s
222	f	440	m
333	ff	002	m
444	f	004	v.s
555	ff	113	m
553	ff	224	f+
551	f—	115	s
		226	f

TABLE II

TYPICAL LAUE DATA FROM AN OCTAHEDRAL PHOTOGRAPH OF TRIMETHYL SULPHONIUM CHLOROSTANNATE

Indices	Spacing	Wave Length	Intensity
$0\bar{4}5$	2.24 Å.	0.483 Å.	f—
$1\bar{4}4$	2.17	.482	f—
$\bar{3}5\bar{1}$	2.11	.446	v.s
$\bar{5}42$	1.86	.401	f
$34\bar{5}$	1.76	.487	ff
$\bar{5}15$	1.75	.392	m
$25\bar{5}$	1.70	.458	f—
$\bar{3}7\bar{2}$	1.58	.475	f

in all probability the correct space group. The atomic arrangement then is as follows:[4]

Tin atoms: 4b.

Sulphur atoms: uuu and other seven positions of 8h.

Chlorine atoms: xyz and other general positions of Ti-6.

Carbon atoms: x′y′z′ and another set of general positions of Ti-6.

The structure of $[(CH_3)_3S]_2SnCl_6$ is, therefore, similar to that[5] of $[(CH_3)_3NH]_2SnCl_6$. Lack of the necessary F-curve data makes unprofitable an attempt to establish exact atomic positions at this time.

THE CRYSTAL STRUCTURE OF DIMETHYL ETHYL SULPHONIUM CHLOROSTANNATE

Data were obtained from Laue photographs and from oscillation photographs using molybdenum radiation. Six comparison spectra were made between the (111) face of $[(CH_3)_2(C_2H_5)S]_2SnCl_6$ and the (100) face of calcite. An average of sixteen reflections taken from the second, third, and fourth orders gives $d_{111} = 7.39$. From this the length of the unit cube edge is $a_0 = 12.80_5$. The density $\rho_{20^\circ} = 1.63$ leads to a unit cube which contains four molecules ($m = 4.04$). Typical data from an octahedral Laue photograph are contained in Table III. Reflections from an oscillation spectrum are listed in Table IV. All agree with a four molecule unit. There is a striking similarity between both the Laue and spectral data and those obtained from $[(CH_3)_3S]_2SnCl_6$. Possible first order reflections with one index zero include only those which are (0, even, odd), so that the space group would appear to be Ti-6.

In several of the other substituted chlorostannates which have been investigated, difficulties have been encountered in placing the hydrocarbon groups in positions which were chemically reasonable and which at the same time conformed to the apparent symmetry. In $[(CH_3)_2(C_2H_5)S]_2SnCl_6$ this seems impossible. No cubic group which could explain the observed diffraction effects has the requisite atomic positions. Ordinarily this would indicate that the crystal was only pseudo-cubic. In the present instance, however, no departure from cubic symmetry could be detected by either goniometric or optical observations. Whether this means that the grouping of the atoms within the substituted sulphonium ion does not partake of the total crystal symmetry or whether these groups in their efforts to attain symmetrical arrangements give rise to a large unit containing 32 molecules cannot be told from the existing data.

[4] Wyckoff, R. W G., The Analytical Expression of the Results of the Theory of Space Groups, Washington, 1930, 2d Ed., p. 127.

[5] Wyckoff, R. W. G., and Corey, R. B., Am. Jour. Sci., 1929, XVIII, 437.

TABLE III

TYPICAL LAUE DATA FROM AN OCTAHEDRAL PHOTOGRAPH OF DIMETHYL ETHYL SULPHONIUM CHLOROSTANNATE

Indices	Spacing	Wave Length	Intensity
$3\bar{1}5$	2.16 Å.	0.497 Å.	v.s
$35\bar{3}$	1.95	.434	m+
$25\bar{4}$	1.91	.426	ff
$34\bar{5}$	1.81	.488	ff
$15\bar{5}$	1.79	.384	m
$52\bar{5}$	1.74	.482	ff
$61\bar{5}$	1.63	.426	f
$73\bar{2}$	1.63	.472	ff

TABLE IV

TYPICAL REFLECTION SPECTRAL DATA FROM A PHOTOGRAPH OF DIMETHYL ETHYL SULPHONIUM CHLOROSTANNATE

[(111) as Principal Spectrum]

Indices	Intensity	Indices	Intensity
220	s	223	ff
440	m	224	m
111	v.s	225	ff
222	f	226	f—
333	ff	227	ff
444	f—	335	ff
113	m+	336	f
114	ff	445	ff
115	m		

THE CRYSTAL STRUCTURE OF METHYL TRIETHYL PHOSPHONIUM CHLOROSTANNATE

No success has attended attempts to prepare large crystals of $[(CH_3)(C_2H_5)_3P]_2SnCl_6$. When solutions of H_2SnCl_6 and the substituted phosphonium hydrochloride were mixed the salt appeared as a white, crystalline precipitate consisting of tiny, clear, optically isotropic octahedra. Even when crystals were formed by slow evaporation of very dilute solutions none was produced of sufficient size to yield Laue or oscillation spectral photographs. For this reason, the data are confined to those given by powder photographs alone. Such data are recorded in Table V. The spacings are the average of those obtained from the measurement of six comparison films against NaCl (Table VI). Pyknometric determination of the density of $[(CH_3)(C_2H_5)_3P]_2SnCl_6$ using benzene as the confining liquid gave $\rho_{20°} = 1.48$. A unit cube having this density and $a_o = 13.93$ Å. will contain four molecules ($m = 4.05$).

No odd order powder lines were found which had other than all odd indices, with the possible exception of the outermost one measured. Other planes might be expected from an arrangement based on the simple lattice Γ_c. It will be remembered, however, that the corresponding ammonium compound, $[N(CH_3)(C_2H_5)_3]_2SnCl_6$, which presumably has the space group T-4, gave data showing no departure from a true face-centered structure of holohedral symmetry. It seems most probable that the structure of $[P(CH_3)(C_2H_5)_3]_2SnCl_6$ is analogous, with

TABLE V

DATA FROM POWDER PHOTOGRAPHS OF METHYL TRIETHYL PHOSPHONIUM CHLOROSTANNATE

Spacing	Intensity	$\sin^2\theta$	Ratio of $\sin^2\theta$	Assigned $h^2+k^2+l^2$	Indices	a_o
1.620 Å.	f	0.04802	73.83	----	----------	----------
1.850	m—	.03684	56.65	56	123(2)	13.968 Å.
1.950	m—	.03316	50.99	51	155(1), 117(1)	13.925
2.209	m	.02583	39.72	40	130(2)*	13.972
2.338	m	.02306	35.46	35 and 36	135(1) and 100(6), 122(2)	----------
2.474	ff	.02058	31.64	32	110(4)	13.995
2.679	s	.01756	27.00	27	115(1), 111(3)	13.920
3.116	ff	.01298	19.96	19 and 20	133(1) and 120(2)	----------
3.480	f	.01041	16.01	16	100(4)	13.920
4.233	s	.00704	10.83	11	113(1)	14.041
						13.963 Å.

*A line having a slightly smaller spacing than 130(2) was plainly visible on all photographs but was too faint to be measured. Estimation would place it at $h^2+k^2+l^2=43$ and thus give it indices 335.

TABLE VI

VALUES OF a_o FOR METHYL TRIETHYL PHOSPHONIUM CHLOROSTANNATE AS AVERAGED FROM COMPARISON FILMS WITH NaCl

Film No.	a_o
1	13.921 Å.
2	13.938
3	13.927
4	13.898
5	13.973
6	13.931
	13.93_1 Å.

tin and chlorine atoms in substantially the same higher symmetry positions that they occupy in $(NH_4)_2SnCl_6$ but with the aliphatic carbon atoms in 4f and the general positions of T-4.

CONCLUSION

Crystals of trimethyl sulphonium, dimethyl ethyl sulphonium and of methyl triethyl phosphonium chlorostannates are cubic with $(NH_4)_2SnCl_6$, or CaF_2, arrangements of their ions. The trimethyl sulphonium and the methyl triethyl phosphonium chlorostannates are like the corresponding substituted ammonium compounds, but with somewhat larger unit cells. Though a departure from cubic symmetry could not be observed for the dimethyl ethyl sulphonium chlorostannate, no set of positions for all its atoms compatible with this high symmetry and its apparent simple structure could be found.

NEW STUDIES ON THE CHEMICAL EFFECTS OF X-RAYS

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ALTHOUGH a fairly large number of facts have been collected concerning the biological effects of X-rays, chemical research on this subject has been very meager up to within a few years. In 1925, however, Miss Chamberlain (1) showed that the reduction of potassium permanganate and of iodic acid and the oxidation of sulfurous acid took place to a very slight extent when these substances were exposed to X-rays. These experiments were merely qualitative.

Workers at the Cleveland Clinic (2) in 1927 studied the transformation of oxyhemoglobin to methemoglobin under the action of X-rays and found that, between the limits 0.527–0.754 Å.U. at least, the amount of chemical action was independent of the wave length of the radiation employed. This study was followed by an extensive investigation, by the same group of workers (3), of the oxidation of ferrous sulfate to ferric sulfate. They reached the conclusions that the chemical effect produced by a given dose was independent of the wave length between the limits 0.204 and 0.765 Å.U.; that this reaction might be used as a chemical method of measuring dosage, and that the oxidation was a secondary effect produced by activated water and dependent on the amount of oxygen dissolved in the water.

Somewhat previous to this work, Glocker (4) undertook the investigation of the action of X-rays upon iodoform in chloroform and other solvents and came to the conclusion that the observed liberation of iodine was dependent on the solvent used, and that the effect noted was a secondary rather than a primary reaction. Later a very careful investigation was carried on by the same author, in collaboration with Risse (5), regarding the action of X-rays upon the decomposition of hydrogen peroxide and of potassium persulfate. Their conclusions were that the chemical action was independent of the wave length between 0.19 and 1.54 Å.U., if only that energy which is transformed into energy of electrons is considered; that the amount of energy necessary for decomposition of hydrogen peroxide under these conditions was 70 cal. per mol, and that all of the electrons produced in the solution were active photochemically.

Günther (6) and co-workers also studied the action of X-radiation on chloroform and iodoform and concluded that HCl and HI were the primary products formed.

Reinhard and Tucker (7) have noted that exposure to X-rays over long periods of time, from 35 to 100 hours, has caused a slight inversion of sucrose both in the crystalline and in the dissolved condition. Fernau (8) made similar observations several years earlier at the same time that he observed the effect of ultra-violet and radium rays.

The action on the silver bromide of a photographic plate is very rapid and obvious to anyone who has worked with X-rays. Eggert and Noddack (9) have made a study of the quantum yield, with the conclusion that one quantum of radiation of about 0.45 Å.U. develops about 1,000 silver atoms and hence one grain of the silver bromide.

Patten and Smith (10) have reported that the action of X-rays upon ammonium thiocyanate turns the latter a dark red.

The reaction between mercuric chloride and ammonium oxalate (Eder's solution) has been suggested as a convenient dosagemeter for soft X-rays by Wyckoff and Ba-

ker (11) and by Quimby and Downes (12). The formation of mercurous chloride which can be weighed occurs to a sufficiently large extent to make the reaction a sensitive method of measurement.

The study of the effect of X-rays on substances which are present in the body has been a popular field for research. Stenström and Lohmann (13) have investigated the action of the rays on certain of the amino acids and have found that while cystine underwent no measurable change, tyrosine in dilute aqueous solution is changed in regard to the phenol group. The ratio of the number of molecules affected to the pairs of ions formed is 1:12. Hussey and Thompson (14) and Clark and Northrop (15) have carried out a series of experiments on the enzymes trypsin, pepsin, and invertase, using radium and X-rays, and have found that all three of these were inactivated. Rothstein (16) also reported on the inactivation of trypsin by X-rays. The inactivation of diastase has been noted by Peskov (17). Insulin (18) is thought to be unaffected by radiation, while the effect on cholesterol seems to be the subject of a difference of opinion. It is destroyed in a medium of chloroform or carbon tetrachloride, but is apparently unaffected in a medium of benzene or carbon disulfide (19) when subjected to radiation. This action is undoubtedly indirect following the formation of oxidizing substances and the effect on cholesterol in the blood is probably very small.

Many of the investigations cited above were carried on simultaneously with this research, while very few of them date back more than three years. The subject of the chemical action of X-rays is evidently one of great interest to X-ray workers at present, and it is very probable that the next few years will bring many further developments in the field.

EXPERIMENTAL

1. Preliminary studies on a variety of reactions.—A number of different reaction mixtures were exposed to X-rays in order to determine what types of substances are sensitive to the radiation. In general, the procedure followed was to expose the specimen in a thin-walled pyrex bulb to polychromatic radiation from a tungsten target of effective wave length 0.24 Å.U. at a distance of eight inches from the focal spot. In each case a control consisting of a similar bulb treated in the same manner and subject to the same temperature but protected from the radiation by a lead shield was used. The following reactions were studied:

(a) Ferrous sulfate.—A 10 c.c. portion of a solution of ferrous ammonium sulfate in 0.04 N H_2SO_4 was exposed to X-rays from a molybdenum tube for 20 hours and then titrated with 0.0101 N $KMnO_4$; 8.18 c.c. of the titrating agent were required for the exposed solution, while 5.85 c.c. were required for the blank. Inasmuch as Kailan had reported a slight reduction of ferric sulfate by radium rays a solution of this substance was exposed in order to determine if a ferric-ferrous equilibrium was reached. However, the exposure of a solution of ferric sulfate for several months to X-rays resulted in no measurable reduction.

(b) Anthracene and dianthracene.—Inasmuch as this equilibrium is very sensitive to ultra-violet light, it seemed possible that it would be affected by the shorter wave radiation. The course of any change could be followed qualitatively very easily since anthracene is soluble in xylene or phenetole, while dianthracene is insoluble and precipitates out of solution as it is formed. However, a saturated solution of anthracene in phenetole was exposed to X-radiation for 46 hours with no effect. The following experiment also served to prove that X-rays have no appreciable effect on the anthracene-dianthracene equilibrium.

A saturated solution of anthracene in xylene was exposed for several hours to ultra-violet light from a mercury arc in quartz with the result that a considerable precipitate of dianthracene was formed. A portion of the original solution of anthracene sealed in a bulb, and a second bulb containing a suspension of the dianthracene formed in xylene were exposed to about 200 hours of raying, during which time no apparent change took place in either.

(c) Fumaric and maleic acids.—Samples of fumaric and maleic acid suspended in water were exposed to X-rays. The former acid is soluble to the extent of only 0.65 gram in 100 g. at 16°, while maleic is soluble to the extent of 50 grams per 100 g. at 10°. It was thought that any change could be detected by the accurate measurement of the temperature at which each of these samples completely went into solution. Measurements of this temperature after 200 hours of exposure to radiation showed no change in either.

(d) Iodine and benzene.—A solution of iodine in benzene sealed in a bulb was exposed to X-rays. One cubic centimeter samples of this and of a similar sample unexposed were titrated with sodium thiosulfate. Results: c.c. of 0.10 N $Na_2S_2O_3$ used: unexposed, 35.70, 35.70; exposed, 32.37, 32.27.

(e) Acetone, iodine, and water.—This reaction is apparently unaffected by X-rays. The high temperature coefficient makes this reaction impracticable for study.

(f) Inversion of sugar in the presence of lead nitrate.—The presence of lead nitrate apparently aids the inversion of sugar under the action of X-rays, but the effect is probably secondary due to a change in P^H. Results obtained after 23 hours of exposure to radiation from a tungsten target tube at 75,000 volts and 4 to 5 milliamperes, lasting over an interval of one week, were as follows:

	Saccharimeter reading at 20°	pH
Sugar solution unexposed	38.8	5.8
Sugar solution exposed to X-rays	38.4	5.8
100 c.c. of sugar solution + 1 c.c. of 10% $Pb(NO_3)_2$	38.2	5.8
100 c.c. of sugar soln. + 1 c.c. of 10% $Pb(NO_3)_2$ exposed to X-rays	36.4	$4.4 < pH < 5.2$

(g) Oxalic acid and uranyl salt sensitizer.—Many investigations have been carried out as to the decomposition of oxalic acid by ultra-violet radiation with some uranyl salt present as a sensitizer. In the work of Anderson and Robinson the reaction seemed to be more sensitive to the shorter wave lengths in the ultra-violet, which suggests that the most effective frequency might lie in the X-ray region. Solutions (1) 0.1 N in oxalic acid and 0.01 M in uranyl acetate, (2) 0.02 N in oxalic acid and 0.002 M in uranyl acetate, and (3) 0.001 N in oxalic acid and 0.001 M in uranyl acetate showed no decomposition after being irradiated 24 hours with the tube operating at 60 kilovolts and 5 milliamperes.

(h) Conclusions.—The results of these preliminary experiments and others described in later sections of this paper indicate that sensitivity to ultra-violet light is no criterion for prophesying a sensitivity to radiation in the region of 0.2–0.3 Å.U. Furthermore, the reactions most affected are those which involve oxidation or reduction in aqueous solution.

The above results shed no light on the question of the physiological action of X-rays. No chemical action yet studied, with the exception of the reduction of the silver bromide on a photographic plate, and the oxidation of ferrous sulfate, is of the same order of magnitude as that change which occurs in body tissue. It is possible that some

chemical reaction sensitive to radiation, whose counterpart has not yet been discovered, may underlie physiological action, or that the latter depends on such an effect as the coagulation of a colloid. Several examples of the latter were investigated, such as the coagulation of egg albumin and of colloidal clays, which give changes of larger magnitude than those observed in the case of chemical reactions. Further studies were discontinued inasmuch as several recent papers by Fairbrother (20) have appeared on the subject.

2. The decomposition of organic mercury compounds.—Since it is possible that some chemical reactions may be affected by secondary radiation from heavier metals, several aromatic mercury compounds were subjected to X-radiation, both in the solid state and dissolved in organic solvents. No change was observed after 12 hours of raying except in the case of α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester, where mercury was liberated.

Preparation of α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester: Twenty-five grams of cinnamic ethyl ester were dissolved in 100 c.c. of methyl alcohol and mixed with an equivalent amount of mercuric acetate dissolved in the least water possible. After three days needles began to appear, but the reaction is slow, so the mixture was allowed to stand 12 days before the compound was purified by recrystallization from ethyl acetate.

The yellowish powder rapidly changed color within a few seconds upon exposure to X-rays.

Solution for radiation: 7.041 gm. of α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester were dissolved in a mixture of 50 c.c. of ethyl alcohol and enough ethyl acetate to make the total volume of the solution 500 cubic centimeters. Fifteen cubic centimeter samples were pipetted into the thin-walled flasks, which were then tightly stoppered and completely covered with black paper to exclude radiation within the limits of the visible region.

The amount of mercury liberated was determined by placing a small piece of gold foil in the flask as soon as it was removed from the lead chamber. A period of 12 hours was allowed for any settling of fine particles of mercury before weighing the foil again. It was established that the amount of mercury liberated was proportional to the time of irradiation, all other factors remaining constant. Flasks protected from the X-radiation by lead shields showed no indication of the liberation of mercury, so it was assumed that the temperature coefficient of the reaction was too small to be determined by this method.

The method suggested by Quimby and Downes was used in measuring the quantity of radiation.

Solutions Used

1. 0.4 N mercuric chloride—

Dissolve 54 gm. of pure mercuric chloride in one liter of hot distilled water. After cooling, filter the solution into the supply bottle.

2. 0.5 N ammonium oxalate—

Dissolve 32 gm. of pure ammonium oxalate in one liter of hot distilled water. After cooling, filter into the supply bottle.

3. 0.1 N in iodine—

Dissolve 45 to 50 gm. of pure potassium iodide in 25 to 30 c.c. of distilled water in a one liter volumetric flask. In this solution, dissolve 12 to 13 gm. of pure iodine crystals, and after they are completely dissolved make the solution up to one liter.

4. 0.1 N sodium thiosulfate—

Dissolve 24.8 gm. of pure sodium thiosulfate crystals in one liter of distilled water. After it has been allowed to stand ten days, it is standardized against potassium bromate. For the actual estimation of mercury this 0.1 N solution is diluted ten or

twenty times to give 0.01 N or 0.005 N sodium thiosulfate as it is needed.

5. 1 per cent starch solution—

One gram of soluble starch dissolved in a little cold water is added to 100 c.c. of boiling water and allowed to boil for five minutes.

Equal volumes of the mercuric chloride solution and the ammonium oxalate solution were mixed just before the solution was to be irradiated. Fifteen cubic centimeter samples of this mixture were pipetted into the same flasks that had been used for the α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester solution and these flasks were placed in the same position with respect to the X-ray tube. After 5 and 7½ minutes of irradiation, respectively, the amount of mercurous chloride formed was determined volumetrically. The solutions were immediately washed with distilled water from the flasks into 50 cubic centimeter centrifuge tubes. After centrifuging for five minutes at 1,900 r.p.m., the supernatant liquid was poured off, the precipitate thoroughly mixed with distilled water, and centrifuged again for five minutes. The determination may be interrupted at this point if necessary. To continue, this wash water was poured off and the mercurous chloride dissolved by adding 1 c.c. of the iodine solution from an Ostwald pipette. When the precipitate was completely dissolved, the iodine solution on the sides of the tube was washed down by a jet of distilled water and the excess iodine titrated with the standard sodium thiosulfate solution. When the solution became light yellow, 1 c.c. of the 1 per cent starch solution was added and the titration continued until the blue color completely disappeared. In the titration of blanks, the same procedure was followed to make the loss of iodine the same.

In order to compare the absorbing power of Eder's solution with that of the solution of α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester, three flasks were filled with 15 cubic centimeter portions of Eder's solution and were placed one on top of another in the order *A*, *C*, *B* in the path of the X-rays. After they had been irradiated for a few minutes, the solutions in *A* and *B* were analyzed as before for the amount of mercurous chloride formed in each. The flasks were then thoroughly cleaned, *A* and *B* were again filled with 15 c.c. of Eder's solution, but *C* was filled with 15 c.c. of the α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester solution. After raying these arranged in the same order, *A*, *C*, *B*, *A* and and *B* were again analyzed. The difference in the amount of mercurous chloride formed in *A* and the amount of mercurous chloride formed in *B* was assumed to be proportional to the energy absorbed by the solution in Flask *C*. From Table I it seems that the absorbing power of Eder's solution and the absorbing power of the solution of α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester are the same, within the limits of the experimental error.

TABLE I

15 C.C. OF EDER'S SOLUTION IN FLASKS *A* AND *B*

60 K.V. AND 5 MA.

	Flask	Time (min.)	Blank c.c. thio	c.c. thio titr.	c.c. thio Hg	mg. Hg	diff. mg. Hg
I	A	7½	9.23	7.80	1.43	2.89	
	B	7½	9.23	8.98	0.25	0.50	2.39
II	A	7½	9.24	7.15	2.09	4.23	
	B	7½	9.24	8.55	0.69	1.39	2.84
III	A	7½	9.29	7.60	1.69	3.42	
	B	7½	9.29	8.78	0.51	1.03	2.39
IV	A	5	9.25	8.21	1.04	2.10	
	B	5	9.25	9.08	0.17	0.34	1.76
V	A	5	9.25	8.00	1.25	2.53	
	B	5	9.25	8.79	0.46	0.93	1.60

Sodium thiosulfate 0.01008 N.
1 c.c. of the iodine solution used to dissolve the precipitate.
Eder's solution in Flask *C* for I and IV.
α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester solution in Flask *C* for II, III, and V.

The Eder's solution used contained approximately 20 grams of mercury per liter, but since the solubility of α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester did

not permit the preparation of a solution of the same concentration, the solution used contained only 6.03 gm. of mercury per liter. After 15 c.c. of Eder's solution had been irradiated for 10 minutes, mercurous chloride equivalent to 4.5 mg. of mercury was precipitated. Irradiation for 14 hours under the same conditions was necessary to precipitate 4.5 mg. of mercury from the α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester solution.

Over a considerable range of voltages and filters, Quimby and Downes (12) found the amount of mercury precipitated by 840 r to be 0.58 mg. per c.c., with an experimental variation of less than 3 per cent. With the X-ray tube operating at 60 kilovolts and 5 milliamperes, from Table I, 1.76 mg. of mercury per 15 c.c. of solution was proportional to the energy absorbed by Eder's solution in 5 minutes.

$$\frac{0.117}{0.58} \times 840 = 170 \text{ r.}$$

Therefore the quantity of radiation absorbed by 1 c.c. of the solution is 34 r per minute.

Assuming that the solution of α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester has the same absorbing power as Eder's solution, 28,500 r are required to precipitate 0.293 mg. of mercury per c.c. from a solution of the organic compound. Such results indicate that a valuable new method for the evaluation of strength of bonds in organic molecules is here available to the chemist.

3. Condensations of aldehydes and ketones.—Reactions in the field of organic chemistry offer many opportunities for the study of the effects of X-radiation with the possibility that much larger changes may be observed than in the examples of inorganic compounds thus far considered. As one promising type was chosen the condensation reaction of aldehydes and ketones, particularly on account of the known photochemical reactions of formaldehydes to form sugars. Claisen and Claparède (21) prepared phenylstyryl ketone by mixing benzaldehyde and acetophenone in equal proportions, saturating with hydrogen chloride gas, and allowing to stand in the cold for 12 hours. The hydrogen chloride was then removed from the product by heating the mixture on the water bath for several hours. The ketone so produced was crystallized from petroleum ether with a yield of 32 per cent. While this reaction has the disadvantage that it will proceed without radiation, it was thought that there might be a distinct catalytic effect in irradiation. Accordingly two samples of each of the several mixtures were placed in exactly the same place, at 50°, one being entirely protected by lead as

RESULTS OF SERIES OF EXPERIMENTS

No.	Aldehyde	G.		G.	HCl	Product Exposed to X-rays G.	%	Control G.	%
1[a]	Benz-	15	Acetophenone	15	2 g.	10.5	35	7.0	23
2	4-OH-Benz-	1	Acetophenone	1	5 drops	1.5	75	1.2	60
3	4-OH-Benz-	1	Benzaldehyde	1	5 drops	0.38	19	0.27	13.5
4[b]	Benz-	30	.....	....	1 c.c. (concd.)	1.5	5	1.4	4.7
5[c]	Piperonal	5	Acetophenone	Excess	10 drops	1.4	14	0.6	6
6	Acetal-	....	Acetone.—Two samples were treated in similar manner but only a small amount of dark red oil was formed, probably due to the formation of para-acetaldehyde.						
7	Salicyl-	....	Acetophenone.—The product formed only with exposure to X-rays is a dark red oil, and not chalcone, which the usual condensation gives. The oil could not be crystallized from alcoholic solution.						

[a] Benzaldehyde + acetophenone → phenyl styryl ketone ($C_6H_5CH = CHCOC_6H_5$).
[b] Melting point of product 125°, probably stilbene, $C_6H_5CH = CHC_6H_5$.
[c] Melting point of product (both) 119–120°, colorless needles.

a control and the other exposed to X-rays from a tungsten target tube with an effective wave length of 0.24 Å. for a period of five hours.

Summarizing the results of these reactions, it may be concluded that the condensation of aldehydes with ketones is markedly catalyzed by X-radiation, while the condensation of aldehyde with aldehyde is affected not at all or to only a small extent by the rays.

4. A test of the theory of hydrogen peroxide formation in the photo-chemical oxidation of potassium iodide and the reduction of potassium nitrate.—Inasmuch as experiments by Glocker have shown that X-radiation influences the decomposition and also the formation of hydrogen peroxide, it seemed possible that the oxidations noted in aqueous solution were merely secondary reactions following the production and subsequent decomposition of hydrogen peroxide from water and oxygen. The following set of experiments was designed to test this hypothesis.

1. Two thin-walled pyrex tubes were filled with a 2 per cent potassium iodide or 0.1 *M* potassium nitrate solution. Through the following devices one was kept saturated with oxygen while the other was freed of the gas, and both were exposed to the same dose of radiation.

(*a*) One was boiled to expel oxygen, cooled in a nitrogen atmosphere, and sealed. The other was provided with an outlet into an absorption bulb of potassium iodide not exposed to the radiation, and a slow stream of oxygen or air bubbled through during the exposure.

(*b*) One was heated to 100° to expel oxygen and sealed at that temperature; the other was saturated with oxygen at 0° and sealed.

The experimental data, which are illustrated by the accompanying graph, Figure 1, revealed the following facts: (1) The decomposition of potassium iodide in the *absence* of oxygen is a straight line function of the dosage of radiation; (2) the decomposition of potassium iodide in the *presence* of an excess of oxygen takes place to a larger extent, and is not in direct proportion to the amount of radiation; (3) the decomposition of potassium nitrate is a straight line function of the dosage of radiation, and is independent of the presence of oxygen; (4) the ratio of molecules of potassium nitrate to molecules of potassium iodide decomposed by the same amount of radiation is 2.90:1.

The following conclusion might, therefore, be drawn from the data: The decomposition of potassium iodide in the first case (absence of oxygen) is independent of any hydrogen peroxide mechanism which requires the presence of oxygen. Even if the objection should be raised that a very slight amount of oxygen might have been retained by the water under experimental conditions, the direct proportionality between dosage of radiation and amount of change would indicate that the concentrations of the initial reactants do not change appreciably, a condition which is true for the water and potassium iodide but not for the oxygen. The reaction occurring would seem to be

$$KI + H_2O = KOH + I + \tfrac{1}{2}H_2$$

Though this reaction would involve a large increase in free energy, the amount of energy absorbed in the radiation is much greater. The production of hydrogen from water under the radiation by X-rays has been noted by Fricke.

In the presence of excess oxygen, however, there is a possibility of the formation and subsequent decomposition of hydrogen peroxide, as suggested by Glocker, and consequent freeing of iodine. This effect might either supplant or merely add to the reaction discussed above; in either case more iodine would be freed, and the relation between dosage and chemical change might not be

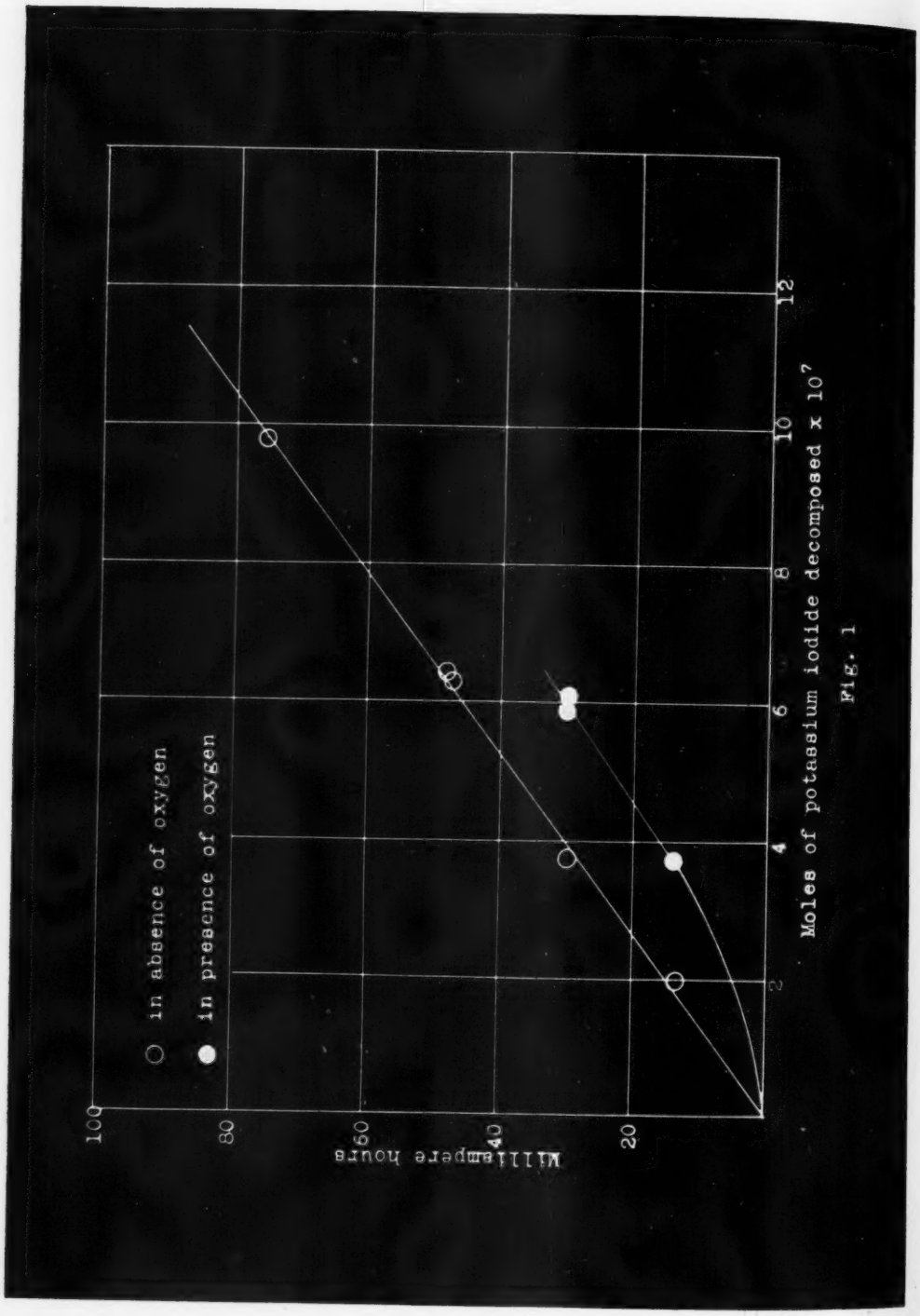
○ in absence of oxygen
● in presence of oxygen
Milliampere hours
100
80
60
40
20
2
4
6
8
10
12
Moles of potassium iodide decomposed x 10⁷

Fig. 1

linear. This conclusion is consistent with the experimental data.

The same reasoning shows that the decomposition of potassium nitrate is independent in any case of the hydrogen peroxide formation. The reaction occurring is $KNO_3 = KNO_2 + \frac{1}{2}O_2$. This is consistent with the fact that hydrogen peroxide does not affect a solution of potassium nitrate but oxidizes a solution of potassium iodide.

Thus it is concluded that the mechanism of the formation and subsequent decomposition of hydrogen peroxide is not essential for oxidation in aqueous solutions. In certain special cases, however, it may play a contributory part in the total effect.

In connection with the above results, tests were made for the presence of ozone and hydrogen peroxide. A stream of oxygen saturated with water vapor was allowed to flow past a thin glass window which was exposed to radiation. The gas was then passed into an absorption tube containing potassium iodide solution. No trace of free iodine was found after an exposure of 15 hours, during which time 12 liters of oxygen passed the window, thus indicating that the formation of ozone, unless immediately decomposed, occurred to a negligible extent.

In order to test for hydrogen peroxide, a tube of distilled water was exposed to radiation for nine hours and opened into a solution of potassium iodide. No free iodine was detected. Glocker reports the detection of a small amount of hydrogen peroxide under similar circumstances. Inasmuch as radiation has been conclusively shown to cause the decomposition of hydrogen peroxide, it is probable that a small amount may have formed and decomposed before detection.

5. Experiments with simultaneous irradiation by ultra-violet light and X-rays.— Some recent evidence has been obtained in this laboratory that the physiological effects of X-rays, for example, on fungi are accentuated by previous or simultaneous ultra-violet irradiation; in other words, the effects of the two kinds of rays are not additive. It was then thought advisable to test this observation with inorganic substances.

Two similar quartz weighing bottles containing 12 c.c., each filled with 0.01 *M* potassium iodate, are arranged so that the light from a mercury arc lamp is evenly distributed between them. One is in the path of X-rays, from which the other is shielded by a lead screen. The temperature coefficient of the reaction is low, but the temperatures are maintained as nearly equal as possible by cooling with a stream of water or of air from two equal openings in the same nozzle. Inasmuch as there is no procedure suitable for directly determining such small amounts of iodine and potassium iodide in the presence of potassium iodate, the following method was adopted: Ten c.c. of the reaction mixture was shaken in a separatory funnel with chloroform. The chloroform layer was drawn off and the residue weakly acidified with 0.4 c.c. of *N* sulfuric acid. Under these conditions the potassium iodide and potassium iodate react to give iodine, which is extracted with chloroform. The extracts are titrated with 0.001 *N* sodium thiosulfate. In a run of three and one-half hours at 70 K.V. and 5 ma., the following results were obtained:

	U. v.	U. v. + X-rays	X-rays
C.c. of 0.001 *N* thiosulfate used	I 0.20 c.c.	0.13 c.c.	.....
	KI 0.10 c.c.	0.20 c.c.	.....
Total	0.30 c.c.	0.33 c.c.	0.03 c.c.

In two other experiments, where the difference was measured qualitatively by the depth of color in the chloroform layer, the potassium iodide was found to be appreciably greater in the tube subjected to X-rays, while the iodine formed in the two cases seemed to be about the same with a little more perhaps in the ultra-violet alone. Apparently the effects of ultra-violet light and X-rays in this case are, within experimental

error, additive. The mechanism of this complicated decomposition as shown by the distribution between iodine and potassium iodide is evidently affected. The additive effect has been further verified more directly in the photolysis of potassium nitrate.

6. Measurement of the intensity of X-rays.—Any quantitative study of the relation between the X-ray dosage and the chemical effect produced necessitates an accurate method of measuring the dosage. An international unit of dosage was established at the International Congress of Radiology at Stockholm in July, 1928, as "the quantity of radiation which, when the secondary electrons are fully utilized and the wall effect of the chamber is avoided, produces in one cubic centimeter of atmospheric air at 0° C. and 76 cm. pressure such a degree of conductivity that one electrostatic unit of charge is measured at saturation current. This unit is called the roentgen and is designated by 'r.' "

Two types of ionization chambers are employed which tend to avoid by different methods the error caused by photo-electrons from the wall and electrodes of the chamber. One is a large chamber designed to prevent wall effects by having the walls and electrodes out of the direct beam and to fully utilize the electrons by the great distance between the electrodes. This type has been used by Duane (*22*), of Harvard, Glasser (*23*), of the Cleveland Clinic, and Taylor (*24*), of the Bureau of Standards at Washington. The second type is of 1 cubic centimeter or less capacity and has walls of as nearly as possible the same atomic number of air; this has been used by Fricke and Glasser (*23*), Glocker (*25*), Behnken (*26*) and others.

A chamber of the latter type was designed and constructed for the present research. This was turned out from Acheson graphite which analyzed as containing 0.2 per cent ash and was of a cylindrical form. The walls were 1 mm. in thickness and the capacity of the chamber was 0.999 cubic centimeter. The wall itself served as one electrode, while an aluminum wire at the center, carefully insulated from the walls, served as the other electrode.

This ionization chamber was placed in a beam of radiation and the saturation current measured with the aid of a calibrated resistance of 1.29×10^9 ohms and a Lindemann electrometer, which was calibrated with a potentiometer with the aid of a standard cell.

7. Energy relations in the photolysis of potassium nitrate by X-rays.—A study has been made of the energy relationships involved in the photolysis of potassium nitrate by X-rays. This reaction has been the subject of much study in connection with the photochemical action of ultra-violet light. The unfiltered radiation from a tungsten target Coolidge tube, operating at 105 K.V. as measured by a sphere gap and 3 ma., was used in this work. The effective wave length, measured by the Duane method, which involves the determination of the thickness of aluminum which has the same absorbing power as 1 mm. of copper, was found to be 0.236 Å. The solutions used were of 0.01 *M* potassium nitrate contained in pyrex glass bulbs which were blown with thin-walled flat sides. Intensity measurements were made of the incident radiation and of the radiation which had passed through the solution. From measurements of the total area exposed the total amount of energy absorbed could be computed. The solutions were analyzed for nitrite by the Warburg method as modified by Villars (*27*), using weight burets and 0.001 *N* thiosulfate.

The results of three entirely independent

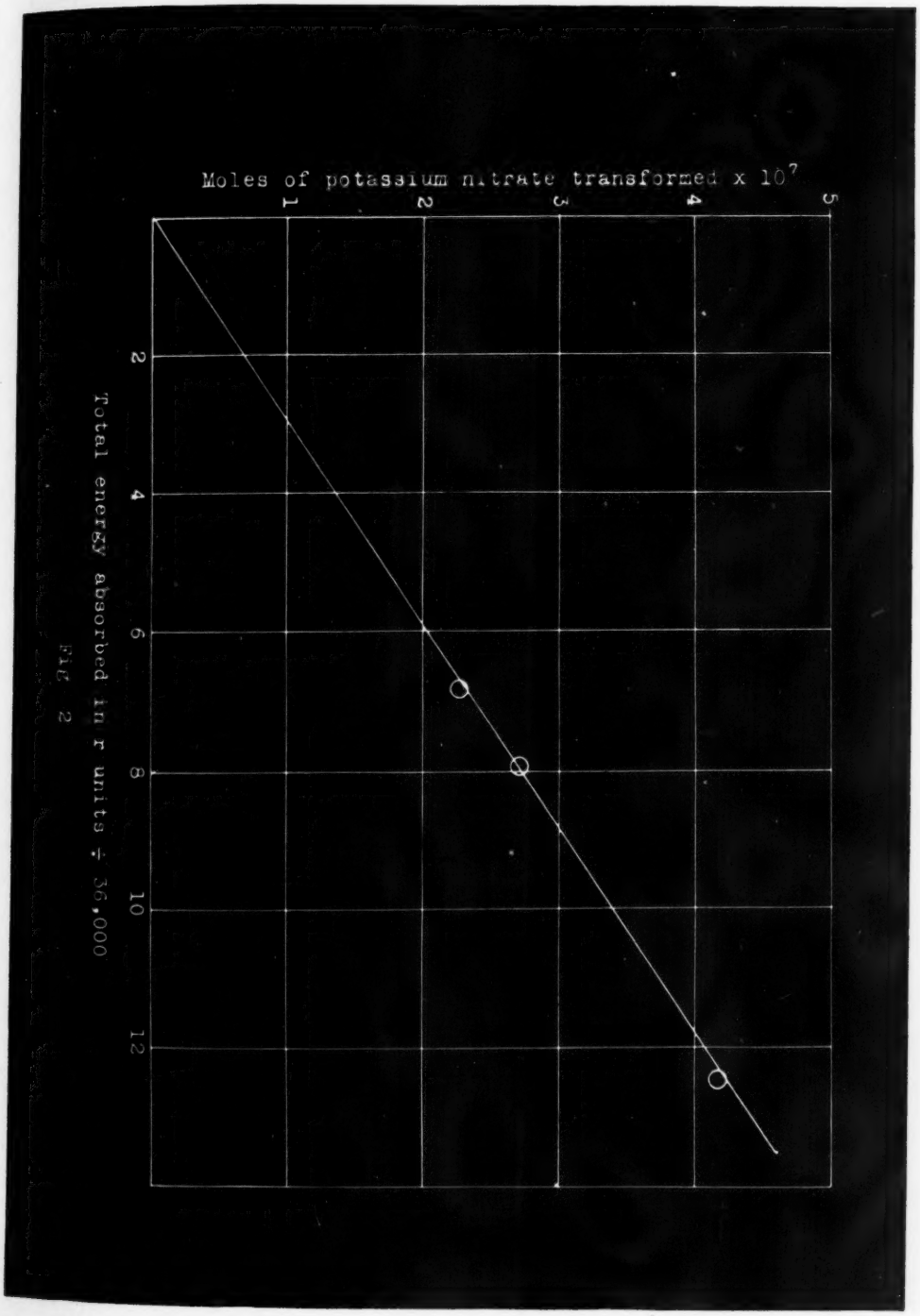
Moles of potassium nitrate transformed x 10^7
1
2
3
4
5
Total energy absorbed in r units ÷ 36,000
2
4
6
8
10
12

Fig. 2

experiments, illustrated in Figure 2, are as follows:

Expt.	Exposed area ($cm.^2$)	Thickness of layer (cm.)	Weight of 0.001 *N* thio, g.	Incident energy per $cm.^2$ per sec., r	Energy absorbed per $cm.^2$ per sec., r
1	15.48	1.62	0.4117	2.56	0.80
2	15.90	1.04	.2702	2.32	.490
3	12.91	1.12	.2291	2.40	.535

Total energy absorbed (10 hrs.)	Molecules reacting per r	Molecules per ion pair *(M/N)*	Energy cal./mole
445,680 r	5.58×10^{11}	0.2–0.3	1.31×10^7
280,476 r	5.83×10^{11}	0.2–0.3	1.25×10^7
248,400 r	5.58×10^{11}	0.2–0.3	1.31×10^7

Fairbrother makes the assumption that a given amount of radiation will produce approximately the same number of ion pairs in a dilute aqueous solution as are produced in the same weight of air, inasmuch as the atomic numbers of air and water are not very different. To allow for relative densities of air and dilute solution, a factor of about 1,000 is involved. If this assumption is adopted, the number of molecules of potassium nitrate which react for each ion pair may be calculated

$$\frac{\text{total energy}}{\text{charge on electron}} = \text{no. ion pairs per c.c. in air} = \frac{10^{10}}{4.774} = 2.1 \times 10^9 \text{ ion pairs per c.c. in air, or}$$

approximately 2×10^{12} ion pairs per c.c. in the solution;

$$\frac{\text{no. molecules reacting}}{\text{no. ion pairs}} = \text{molecules per ion pair}$$

Using the data given above, the values for the latter are between 0.2 and 0.3 for this endothermic decomposition of potassium nitrate. The number of molecules per ion pair may be calculated independently from the energy in calories per mole and the work required to form one ion pair (35 volts): $(1.313 \times 10^7$ cal./mole $KNO_3)$ / $(23{,}000 \times 35$ cal./mole ion pairs), or approximately 0.1 molecule of potassium nitrate per ion pair. This is in satisfactory agreement with the value calculated above, considering experimental difficulty, and with the order of magnitude to be expected thermodynamically.

In order to express results in terms of absolute energy, the absorption coefficients and the fraction of the absorbed energy which is converted into the kinetic energy of electrons and thence into the work of formation of ions must be known. The absorption coefficient, 0.228, as calculated from the above data, agrees very closely with the value for absorption of the same wave length in water interpolated from a series of values given by Glocker. The fraction of the total absorbed energy converted into work of formation of ions is the ratio of the values of the absorption coefficients for the energy given to recoil and photo-electrons to that of the total absorption coefficient. Using values recorded by Glocker, this fraction for the effective wave length used is 0.263.

The absorbed energy as measured in r may be converted into ergs by the use of the formula proposed by Rump (28) and Kulenkampff's (29) experimental value of 35 volts as the work required to form one ion pair in air

$$\frac{E}{i} = \frac{\epsilon}{0.36}\left(\frac{\rho}{\tau + \sigma_v}\right)$$

where $E/i = 1944$ ergs/r, ρ = density, $\epsilon = 35$ volts, and $\tau + \sigma_v$ = absorption coefficient attributed to recoil and photo-electrons.

Thus the total energy absorbed in Expt. 1 is $445{,}680 \times 1944$ ergs, the fraction 0.263 of which is transformed into work of ionization. At the same time 4.117×10^{-7} moles of potassium nitrate are transformed. Thus the energy rate is 1.313×10^7 cal./mole of reactant.

The heat of decomposition of potassium nitrate calculated from band spectra of oxygen and thermochemical data (30) is 1.03×10^5 cal./mole. Thus it seems evident that not more than 0.8 per cent of the energy absorbed and utilized in formation of ions in the solution appears as chemical dissociation of the molecule of potassium nitrate.

8. X-rays and colloidal lead.—Since the discovery by Blair Bell in England that in the treatment of cancer injection of colloidal lead followed by irradiation with X-rays materially increases the therapeutic benefits beyond those from radiation alone, there has been a great interest in the mechanism involved. There are two possibilities: that the finely divided lead produces secondary X-rays *in situ* in the tissues, or that the lead has a specific chemical effect in the tissues entirely apart from any interaction between the colloid and X-rays. In an effort to throw some light upon the mechanism, several experiments have been undertaken with colloidal lead and simple inorganic systems instead of the complex biological tissues.

Preparation of colloidal lead.—Solutions of colloidal lead were prepared in various dispersion media by the Bredig arc method, using pure lead electrodes of 6 mm. diameter held in an adjustable spark gap device. The beaker in which the colloid was prepared was surrounded by an ice-bath at all times. Some preparations were carried out in a nitrogen atmosphere. Much of the lead used was prepared by the following procedure. An arc was maintained for 10 minutes in 300 c.c. of water redistilled from alkaline permanganate, and having a P_H of 6.6 as measured by Pierre and Fudge's method. The product was centrifuged at 1,200 r.p.m. for 25 minutes and 1,600 r.p.m. for five minutes, siphoned off into containers and covered with a layer of paraffin. In some cases 0.1 c.c. of 1 per cent acetic acid was added to 30 c.c. of colloidal lead before sealing.

The colloidal lead is black in thick layers and brown in thin layers or at high concentrations. It is stable for months when protected from the air but decomposes rapidly when exposed to air to form a white suspension determined by Telkes (31) as lead carbonate. It is much more stable in a nitrogen atmosphere but decomposition is not entirely prevented. Boiling does not affect the stability. Colloidal lead is coagulated by electrolytes and is a rather vigorous reducing agent. When it is placed in a U-tube fitted with electrodes the boundaries may be seen to move toward the cathode, indicating that the particles are positively charged.

Table II (page 258) lists the results obtained in several preparations.

The method used by Telkes for analysis was followed with slight modifications. A 25 cubic centimeter sample of colloidal lead was dissolved in 0.8 c.c. of 10 per cent acetic acid. Standard potassium dichromate was added in excess and the precipitate allowed to settle. The precipitate was then filtered off, and to the filtrate and washings were added 5 c.c. of concd. hydrochloric acid and 5 c.c. of 10 per cent potassium iodide. The iodine freed was titrated after three minutes with standard thiosulfate, using starch indicator.

Effect of X-rays on the coagulation of colloidal lead.—According to Crowther and Fairbrother, positive colloids are coagulated by exposure to X-rays and consequently this effect should be noted in the case of colloidal lead. A series of experiments seemed to show that the lead was not coagulated but even stabilized to a slight extent.

1. Ten c.c. of colloidal lead was placed in each of two thin pyrex test tubes and covered with a paraffin seal. One was exposed for 30 minutes at a distance of ten inches from the target of a tungsten target tube running at a voltage of 60,000 and a cur-

TABLE II

PREPARATION OF COLLOIDAL LEAD

	Dispersion Medium	Time (min.)	Arc (amps.)	Volts	Centrifuge (Min.)	Centrifuge (R.p.m.)	Pb per 100 g. of Soln.	Remarks
1	Redist. H_2O[a]	10	2.5	40	5	840	0.04451	....
2	Redist. H_2O	10	2.6	40	5	1200	.04451	....
3	Redist. H_2O	15	2.8	40	{20	1200	.05583	....
					{10	1800	.05470	[b]
4	Redist. H_2O	12	2.8	30–40	{20	1600	.....	[c]
					{ 5	1800	.....	[c]
5	95% Alcohol	5	2.8	35	{10	1200	.....	[d]
					{10	600	.....	[d]
6	10% Sucrose	10	2.8	35	20	1200	.05015	[e]

[a] Plus one drop of 0.1 *N* sodium hydroxide (P[H] 7). [b] Some further settling out at higher rate of centrifuging. [c] 0.1–0.2 c.c. of 1 per cent acetic acid added to tubes before sealing. [d] Coagulated. Partially settled. Some remained as colloid for over a week. [e] Less stable on standing than water solution.

rent of 4 to 5 amperes, while the other (unexposed) was maintained at nearly the same temperature; 0.6 c.c. of 2.7 per cent calcium chloride was added to each and the tubes were viewed against a brightly illuminated background. Eight minutes elapsed before coagulation was visible in the unexposed, eleven minutes for the exposed.

2. The experiment was repeated using a 145-minute exposure at a voltage of 70,000; 0.4 c.c. of 0.5 per cent sodium chloride was added to coagulate and 45 minutes were necessary to obtain visible coagulation of the unexposed, while 53 minutes were required for the exposed. This result was duplicated.

3. Two tubes of lead which had been prepared for over a month were placed in the X-ray housing, five inches from the target, one protected by a lead shield, and exposed for ten and one-half hours. A slight amount of decomposition was evident in both; 0.5 c.c. of sodium chloride was added to each. In two minutes both had coagulated but the liquid in the case of the unexposed was clear, showing complete coagulation, while the other had the brown color of dilute colloidal lead, evidencing incomplete coagulation lasting for over an hour.

4. The action of rays from a molybdenum target tube operating at 30,000 volts had no apparent coagulatory effect on colloidal lead in a pyrex glass bulb 0.0035 mm. in thickness.

Secondary radiation from colloidal lead.—A very thin walled pyrex tube 7 mm. in diameter and 10 mm. in length was adjusted so that a beam of X-rays from a pinhole would pass down the length without hitting the walls of the tube. Around this a piece of film was placed in a cylindrical holder of radius 2 centimeters. A blank taken with a ten-minute exposure of the empty tube showed no effect upon the film. The film was completely blackened in a ten-minute exposure when the tube was filled with water. With the tube filled with colloidal lead, the blackening decreased with increase in distance from the point where the beam entered the column of lead and increased with time of exposure. It is evident that the intensity of secondary rays produced from the lead when measured at a given distance from the primary beam is very much less than that for secondary rays from water under identical conditions.

Effect of colloidal lead upon a chemical reaction.—The inversion of sugar was chosen for investigation because the reaction in neutral or alkaline solution has been found to be very slightly accelerated by X-rays. A series of experiments shows that the reaction is not appreciably affected by the presence of colloidal lead during the exposure to X-rays.

1. A 5 per cent solution of sugar with specific rotation at 20° of 66.5 was prepared. Tests showed that the rotation was not affected by several days' standing or pro-

longed heating at 30°. Then 25 c.c. of this solution with 2 c.c. of a 0.05 per cent solution of colloidal lead was sealed in a bulb and exposed to X-rays. A similar bulb was protected from the rays. At the end of a six-hour exposure at 60,000 volts and 2 to 5 ma., the lead was dissolved by 0.1 c.c. of *N* acetic acid and the rotation measured. The two readings checked exactly.

2. A solution of colloidal lead in sugar solution was made by arcing for five minutes in a 5 per cent sugar solution and centrifuging for 20 minutes at 1,200 revolutions per minute. After a four-hour exposure at 70,000 volts and 4 ma. the saccharimeter reading of 38.3 was found to be identical for the solution containing colloidal lead and the original solution similarly exposed to X-rays.

3. Colloidal lead was prepared in a 5 per cent sugar solution and a similar experiment carried out using an irradiation of 17½ hours. The following data were obtained:

Solution	Sacch. reading, 20°	PH
Original sugar solution	19.1	6.8
Sugar solution exposed to X-rays	19.07	6.8
Sugar soln. contg. coll. lead, 0.05 g. per 100 g. of soln.	19.15	
Sugar soln. contg. coll. lead exposed to X-rays	19.13	7.8
Sugar soln. contg. $Pb(NO_3)_2$ exposed to X-rays	18.85	5.6

Inasmuch as acetic acid had to be added to the lead in order to dissolve it, P^H measurements could not be made. The value given was for an undissolved portion which had been exposed to the air and had formed the white cloudy lead carbonate, which did not interfere with the colorimetric measurement but showed nothing about P^H of colloidal lead except that it was not acid.

It may be concluded that colloidal lead has no effect upon the inversion of sucrose by X-rays; a considerable effect is observed in the presence of lead nitrate, but the change in P^H alone may account for this. Hence upon the basis of these experiments the mechanism of the action of colloidal lead in the tissues seems to be the specific chemical effect, rather than the production of secondary rays. This agrees with the recent observation that colloidal gold, which should produce secondary rays as easily as lead, has no beneficial effects whatever in the Blair Bell technic.

9. *The flocculation of colloidal clays.*—The action of X-rays in flocculating colloids is an established fact. Clay solutions are usually highly colloidal. It was the purpose of this experiment to find out the action of X-rays on the clay slips. It was taken for granted that flocculation bears a direct relationship with the viscosity of the slip, that is, flocculation increases with viscosity, other things being equal.

Advantage was taken of this relationship, therefore, by first taking a measurement of the viscosity of the slip before raying, and then after raying for a certain time. The change of viscosity is a direct measure of amount of flocculation.

The viscosity was measured by means of a viscosimeter. A certain volume of the solution was allowed to drain off continuously from a large capillary, and the time recorded accurately by means of a stop watch. The following formula expresses the relative viscosity of a slip

$$V = \frac{t_s \cdot S_s}{t_w \cdot s_w}$$

where V is relative viscosity of the slip, t_s is the time required for 100 c.c. of the clay slip to flow through the viscosimeter (in seconds), S_s is the specific gravity of the clay slip, t_w is the time required for 100 c.c. of distilled water at the same temperature of the slip to flow through the viscosimeter (in

seconds), and s_w is the specific gravity of water at that temperature.

The clay slips were enclosed in 1-liter glass vessels tightly closed and exposed to radiation from a molybdenum target X-ray tube at 30,000 volts for 1,200 milliampere-hours.

The data and calculations are as follows:

1. Florida Kaolin:
   t_s = time for 100 c.c. of slip before raying to flow through the viscosimeter = 21 sec.
   t_w = time for 100 c.c. of water to flow through the viscosimeter = 12.0 sec.
   t'_s = time for 100 c.c. of slip after raying to flow through the viscosimeter = 21 sec.
   S_s = 1.210 = specific gravity of the slip.
   s_w = 1.0 = density of water.
   Relative viscosity before raying = $\frac{21 \times 1.210}{12 \times 1.00} = 2.12$, the same as that after raying.
   Hence X-rays have no effect of flocculation on Florida kaolin, which is a very pure kaolin.

2. Anna, Illinois, Kaolin:
   t_s = 25 sec. before raying.
   t'_s = 29 sec. after raying.
   S_s = 1.197.
   t_w = 12 sec. s_w = 1.0.
   V before raying = (25 × 1.197) / (12 × 1) = 2.49.
   V after raying = (29 × 1.197) / (12 × 1) = 2.90.
   Increase in relative viscosity due to raying, 16.5 per cent.

3. Tennessee Ball Clay No. 5:
   t_s = 22.5 sec. before raying.
   t'_s = 25.5 sec. after raying.
   S_s = 1.200.
   V before raying = (22.5 × 1.20) / (12 × 1) = 2.25.
   V after raying = (25.5 × 1.20) / (12 × 1) = 2.55.
   Increase in relative viscosity due to raying, 11.8 per cent.

An analysis of the latter two clays shows that they are impure kaolins containing some proteins and other organic substances; the increase in relative viscosity due to raying is a relative measure of the amount of protein substance present, since the pure Florida kaolin is entirely unaffected. Therefore, the protein is most sensitive to coagulation and affects the slips markedly even though present in very small amounts.

The authors are indebted to Mr. T. Kurosawa and to Mr. D. T. Shaw for assistance in making observations, respectively, on the condensation reactions and on the coagulation of colloidal clays.

SUMMARY

1. Several chemical systems which are known to undergo photochemical change in ultra-violet light are investigated with X-rays, in most cases of an effective wave length of 0.24 Å. Most of the changes, if any, are very small.

2. The most sensitive reactions found besides oxidation of solutions of ferrous to ferric salts are a series of aldehyde-ketone condensations, investigated photochemically for the first time. Aldehyde-aldehyde condensations are much less affected by X-radiation.

3. X-rays split out metallic mercury from α-acetoxymercuri-β-methoxy hydrocinnamic ethyl ester, 0.293 mg. of mercury being precipitated by 28,500 r.

4. The energy relations involved in the photolysis of potassium nitrate by X-rays are quantitatively determined, including an accurate measurement of intensity and dosage in r with a 1 c.c. air-wall ionization chamber. There are 5.58×10^{11} molecules reacting per r, or approximately 0.2 molecule per ion pair. The energy in calories

per mole is 1.31×10^7. Thus less than 0.8 per cent of the energy absorbed and utilized in the formation of ions in solution appears as chemical dissociation of the potassium nitrate molecule.

5. Simultaneous irradiation of potassium iodate and potassium nitrate solutions with X-rays and ultra-violet light produces additive chemical effects in contrast with non-additive biological effects on fungi, etc.

6. A thorough test is made in potassium iodide and potassium nitrate solutions of the theory that chemical effects are secondary and due to the formation of hydrogen peroxide.

7. Colloidal lead used in the Blair Bell technic for cancer therapy is studied from the standpoints of preparation, stability, coagulation by X-rays, production of secondary X-rays, and catalytic effect in reactions subjected to irradiation. The specific chemical effect rather than the action of producing secondary X-rays *in situ* in the tissues is indicated.

8. The coagulation by X-rays as determined by viscosity changes of colloidal clay slips is found to be a function of the amount of organic protein materials present.

REFERENCES

(1) CHAMBERLAIN, KATHERINE: Physical Rev., November, 1925, XXVI, 525.

(2) FRICKE, HUGO, and PETERSEN, B. W.: Am. Jour. Roentgenol. and Rad. Ther., June, 1927, XVII, 611.
Idem: Strahlentherapie, 1927, XXVI, 329.

(3) FRICKE, HUGO, and MORSE, STERNE: Am. Jour. Roentgenol. and Rad. Ther., November, 1927, XVIII, 426.
Idem: Strahlentherapie, 1927, XXVI, 749.
Idem: London, Edinburgh and Dublin Phil. Mag., January, 1929, VII, 129.

(4) BAUMEISTER, L., and GLOCKER, R.: Ztschr. f. phys. Chem., 1921, XCVII, 368.

(5) GLOCKER, R., and RISSE, OTTO: Ztschr. f. Physik, May 21, 1928, XLVIII, 845.
RISSE, OTTO: Ztschr. f. phys. Chem., 1929, Abt. A, CXL, 133.

(6) GÜNTHER, PAUL, VON DER HORST, H. D., and CRONHEIM, GEORG: Ztschr. f. Elektrochem., September, 1928, XXXIV, 616.

(7) REINHARD, M. C., and TUCKER, K. L.: RADIOLOGY, February, 1929, XII, 151.

(8) FERNAU, A.: Kolloid-Ztschr., August, 1923, XXXIII, 89.

(9) EGGERT, J., and NODDACK, W.: Ztschr. f. Physik, May 31, 1927, XLIII, 222.
Idem: Ztschr. f. Physik, Nov. 12, 1928, LI, 796.

(10) PATTEN, C. G., and SMITH, H. D.: Trans. Royal Soc. Canada, May, 1928, Series 3, XXII, 221.

(11) WYCKOFF, RALPH W. G., and BAKER, LILLIAN E.: Am. Jour. Roentgenol. and Rad. Ther., December, 1929, XXII, 551.

(12) QUIMBY, EDITH H., and DOWNES, HELEN R.: RADIOLOGY, May, 1930, XIV, 468.

(13) STENSTRÖM, WILHELM, and LOHMANN, ANNE: Jour. Biol. Chem., October, 1928, LXXIX, 673.

(14) HUSSEY, RAYMOND G., and THOMPSON, WILLIAM R.: Jour. Gen. Physiol., May, 1923, V, 647.
Idem: Jour. Gen. Physiol., September, 1923, VI, 1.
Idem: Jour. Gen. Physiol., November, 1925, IX, 211; January, 1926, IX, 309; 315.

(15) CLARK, HARRY, and NORTHROP, JOHN H.: Jour. Gen. Physiol., September, 1925, IX, 87.

(16) ROTHSTEIN, KARL: Am. Jour. Roentgenol. and Rad. Ther., December, 1927, XVIII, 528.

(17) PESKOV: Bull. Inst. politekhnicheskii Ivanovo-Voznesenskii, VII, 119.

(18) DEN HOED, D., DE JONGH, S. E., and PEEK, A. E. J.: Biochem. Ztschr., Jan. 24, 1929, CCV, 144.

(19) MATTICK, WALTER L., and BUCHWALD, KENNETH: Jour. Cancer Research, 1927, XI, 86.
DOGNON, A.: Compt. rend. Soc. de Biol., Nov. 19, 1926, XCV, 1433.
MACFATE, R. P., and BACHE, A.: Am. Jour. Roentgenol. and Rad. Ther., August, 1927, XVIII, 150.
ROFFO, A. H., and CORREA, L. M.: Boletin d. Inst. de Med. Exper., November-December, 1924, I.

(20) CROWTHER, J. A.: and FAIRBROTHER, J. A. V.: London, Edinburgh and Dublin Phil. Mag., August, 1927, Series 7, IV, 325.
FAIRBROTHER, J. A. V. (communicated by CROWTHER, J. A.): Brit. Jour. Radiol., April, 1928, I (n. s.), 121.
FAIRBROTHER, J. A. V.: London, Edinburgh and Dublin Phil. Mag., September, 1928, Series 7, VI, 385.

(21) CLAISEN, L., and CLAPARÈDE, A.: Ber. Deutsch. Chem. Ges., Nov. 14, 1881, XIV, 2460.

(22) DUANE, WILLIAM: Am. Jour. Roentgenol. and Rad. Ther., December, 1923, X, 935.

(23) FRICKE, HUGO, and GLASSER, OTTO: Cited in GLASSER, OTTO, and PORTMANN, U. V., Am. Jour. Roentgenol. and Rad. Ther., January, 1928, XIX, 47.

(24) TAYLOR, LAURISTON S.: Bureau of Standards Jour. Research, 1929, II, 771.

(25) GLOCKER, R., and RISSE, O.: Ztschr. f. Physik, May 21, 1928, XLVIII, 845.

(26) BEHNKEN, HERMANN, and JAEGER, ROBERT: Ztschr. f. tech. Physik, 1926, VII, 563.

(27) VILLARS, DONALD S.: Jour. Am. Chem. Soc., February, 1927, XLIX, 326.

(28) RUMP, WALTHER: Ztschr. f. Physik, May 31, 1927, XLIII, 254.

(29) KULENKAMPFF, HELMUTH: Ann. d. Physik, 1926, LXXIX, 97.

(30) VILLARS, DONALD S.: Unpublished material.

(31) TELKES, M.: Jour. Am. Chem. Soc., May, 1927, XLIX, 1382.

RADIATION SENSITIZATION, WITH CASE REPORT[1]

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ALLERGIC reactions of the body to various physical agents, including visible light, are well known, but little is found in the literature regarding similar effects produced by X-rays or radium. The following case is presented with the query: Is this a case of radiation sensitization?

CASE HISTORY

S. M. A., female, aged fifty-two, appeared January 15, 1923, for post-operative radiation for carcinoma of the left breast, at which time the following history was obtained. Her father died at seventy-six, of cerebral hemorrhage; her mother died at seventy-four of pneumonia; one sister died of typhoid at eighteen, and another of subphrenic abscess at twenty-nine; two sisters and one brother died in infancy, from causes unknown to her. She had always been well until she developed a carcinoma in the right breast, which was removed in June, 1922. A little later a gland in the right supraclavicular space was found, and extirpated. Shortly after this she developed a lump in the left breast, which was removed in October, 1922. One month later the left supraclavicular glands became painful to touch and were operated on. The pathological report showed active medullary carcinoma and adenocarcinoma of the lymph glands, with areas of necrosis. At the time of her appearance for post-operative radiation, the physical examination was essentially negative. The urinalysis showed a faint trace of albumin, and an occasional small, finely granular cast, but was otherwise normal. The blood count showed hemoglobin 90 per cent; the red cells, 4,500,000; the white cells, 5,980; the differential, 66 polymorphonuclears, 18 small and 12 large lymphocytes, 1 eosinophile, and 3 transitionals.

The patient was given deep therapy over the left thorax, through anterior, left lateral, and posterior points of entry, each with the following technic: 200 K.V., 6 ma., 50 cm. target-to-skin distance, filter 0.75 Cu, 1 Al, 20 x 20 field, time 2 hours. The left cervical glands, axilla, and breast regions were exposed, followed by a slight primary erythema, sharply demarcated over the area treated, which disappeared within twenty-four hours. There was considerable nausea for several days following the radiation. A severe reaction followed, but the skin recovered without subsequent atrophy.

A solidification of the left lung afterwards developed, and in June, 1923, a roentgenogram showed fluid in the left pleural cavity, from which 280 c.c. of a clear yellowish fluid was removed. A month later an operation was done in the right supraclavicular space, but no glands were found. The right arm was swollen and an unusually persistent cough was present. The temperature and pulse were normal. In August of 1923 chest stereograms showed a clearing of the fibrosis in the left lung. Roentgenograms of the shoulder girdles were negative for bone metastases. In November, 1923, radium was applied to the right supraclavicular glands. Two areas were treated with 50 mg. filtered through 1 mm. of brass at 1 cm. distance for six hours, and three areas in addition with the same technic the next day. Further radium was given to the right neck in January, 1924, when seven hours to each of two areas was administered. The blood count then showed: 90 per cent hemoglobin; 8,600 whites; differential, 60 per cent polymorphonuclears, 13 small and 21 large lymphocytes, 3 eosinophiles, 1 basophile, and 2 transitionals. Two

[1]Read before the Radiological Society of North America at the Fourteenth Annual Meeting, at Chicago, Dec. 3–7, 1928.

months later, twelve hours of radium, 50 mg. at 1 cm. distance with 2 mm. brass were applied in one area of the left neck. In June, 1924, the right supraclavicular region was treated over one area with the same filtration and distance. In September, 50 mg. for five hours was placed over the left neck, with the same technic. Moderate radiation sickness after each treatment was the rule.

Exactly one month from this treatment, while teaching in the classroom, the patient, who previously had been quite well, suddenly was seized with a pain about her heart so severe that she was assisted home immediately and put to bed. She became worse rapidly and was soon cyanotic, almost pulseless, and had marked difficulty in breathing Soon afterwards, when her physician arrived, she had revived slightly. He found her pulse 120 and the temperature 103 degrees, and administered morphine and some preparation of digitalis. The cyanosis increased rapidly, so that soon the fingers and hands as well as the face were blue. She complained of feeling cold and hot water bottles were put around her. The left arm began swelling during the night, until it was twice normal in size, hard and firm to the touch, and did not pit easily on pressure. Severe itching of the skin of the chest and arms was present, and these parts became very red towards evening. Her brother, a surgeon from a near-by city who was called, reports that the urine was negative at that time. The erythema continued for three days; then her right arm began to swell and both reached such size that she could move neither. The pulse and temperature remained about the same. Vomiting was so severe throughout the attack that no food was retained. Gradual improvement from this time on was seen. The swelling in the arms began to recede towards evening, but returned towards noon the following day. One week from the onset, the arms were practically normal in size; two days later she sat up, and soon made a rapid and apparently complete recovery.

She returned November 11, 1924, for examination, feeling perfectly well, and told of her recent attack, concerning which, however, she was somewhat indefinite. It was considered that she probably had had a pneumonia, and as there were palpable glands still present in the left neck, she was given 50 mg. of radium through 1 mm. of brass, 1 cm. distance, over one area, for eight hours. She was slightly nauseated during the night, but remained perfectly well until December 8, 1924, twenty-seven days after radium was last applied. At that time she was taken suddenly ill, and had practically an exact repetition of the symptoms of the previous attack, except more severe. Her temperature rose abruptly to 107, and reached 108. There was marked swelling of all parts of the body, including the lower and particularly the upper extremities, and large wheals over the chest were present. There was severe redness and itching of the skin. The heart was greatly embarrassed, respiration was labored, with inspiratory dyspnea, and moist râles were heard over both lungs. The symptoms rapidly grew worse and no medication, including adrenalin, had any noticeable effect. She died from this most fulminating illness three days after the onset of symptoms. No autopsy was done.

The case reported suggests at least the possibility that the symptoms were the result of radiation. The literature describes the immediate effects of exposure of the body to radiation, also the local inflammatory reaction, but is very meager in describing later effects. De Courmelles, in 1924, under the title of "Radioanaphylaxis," describes a case of sensitization to radiation. Ten X-ray treatments for uterine fibroid were followed after a considerable lapse of time by a return of the symptoms, for which

another series of treatments were given. After the last series the patient had a temperature of 40° C., with nausea, vomiting, and diarrhea, accompanied by great prostration. The interval between the treatment and the onset of symptoms is not given, but the case is at least strongly suggestive of his title—radioanaphylaxis. He states that he has observed other cases of severe reaction where a long interval has elapsed between series.

Tuffier, in 1924, reported a case of radiation given over the dorsal vertebræ, from the sixth to the tenth, for metastases from carcinoma of the breast. The patient had had considerable radiation for two years previously over the left hip, vertebral column, and chest. No initial reaction followed the first series, but later vomiting for 48 hours after each treatment occurred. She was treated finally over the dorsal vertebræ, from the sixth to the tenth, and nearly a month later uncontrollable vomiting appeared, which was continuous, the vomitus containing blood. The pulse was 140, but there was no temperature. Adrenalin was administered, and the patient, who had been practically moribund, recovered. Tuffier attributed the reaction to damage to the adrenals. This case suggests a sensitization reaction, although the adrenals were exposed and probably were affected. The patient, however, recovered completely, so that marked permanent damage to the adrenals probably did not occur. The relief after adrenalin could have followed either or both.

Schmitz states that the part played by autolytic ferments in radiation sickness must remain an open question. Severe reactions, he believes, are more likely to follow irradiation over carcinomatous cervical glands than in cases of early carcinoma with few degenerative changes or with recurrent carcinoma, and he believes that the symptoms are the result of absorption into the circulation of protein liberated by destruction of cells. Acute symptoms of radiation, he states, "may come on within a few hours or may be delayed for days or even weeks." He distinguishes between symptoms of acute constitutional intoxication and those caused by injury to the tissues and organs exposed to the X-ray, which are inflammatory and occur in from fourteen to twenty-one days. The necrotic carcinoma cells in the neck, as noted by Schmitz, were present in the writer's case, and the initial sensitizing doses were certainly adequate.

Lignac, in 1924, in discussing the pathogeny of disease from penetrating radiation, says: "Cytolosis is never produced immediately after radiation; biopsy shows a modification of the radiated cells only some days afterwards, about ten to fifteen. At this time an important reaction appears, and in some neoplasms, as in the neck or mouth, for instance, an edema may be seen to appear, bringing about serious local symptoms, and also, some general phenomena—malaise, temperature, and diarrhea. These secondary phenomena are explained by resorption of destroyed cells, and from this time begins the diminution of the tumor. It is these symptoms that really constitute radiotoxemia." As Lignac states, it is logical to expect relief after adrenalin whether the patient is sensitized or not, as both conditions differ only in degree. He states, in conclusion, that "Adrenalin seems to be the rational treatment, preventative as well as curative, in this disease."

The late symptoms of radiotoxemia, as described by Schmitz, are those of absorption of necrotic proteins, and differ from those in the writer's case in that no sensitizing of the patient to previous radiation had occurred. The symptoms in unsensitized cases should be more mild because no autolytic ferments are present in sufficient quantity to produce sudden splitting up of necrotic cells, resulting in allergic shock. If, however, the patient is subjected at some

time to a dose of radiation sufficient to produce extensive necrosis of tissue, then we have a sensitizing dose, which should cause ferments to be formed in sufficient quantity so that the patient thereafter becomes sensitized to further radiation. Then, any time afterwards, when cells are killed by radiation and thrown into the circulation, a rapid splitting up occurs, because the ferments are already present, and can act immediately.

The case cited presents a strong similarity to cases of allergy from other causes. There are certain factors, however, which may enter into the case, the effect of which can not be ignored. For example, the original radiation may have caused injury to the heart muscle, producing necrosis of cells and gross damage, which later may have given rise to intrinsic cardiac symptoms. R. A. Cooke, of New York City, in a personal communication, suggests that there may have been a cardiac collapse, possibly associated with hydropericarditis, but believes that the reaction in this case might well be due to a sensitization resulting from tissue damage due to radiation. He adds further that he can see no reason why involution of tissue following radiation should not give rise to a sensitization. The split products from radiation acting on the heart muscle could, he believes, have produced the cardiovascular collapse. The negative urinary findings rule out a renal basis for the attacks. Injury to the bronchi or mediastinum may have occurred for the same reason. It is, however, difficult to reconcile the symptoms which appear typical of angioneurotic edema with any of these possible explanations.

Duke has shown that the body may be sensitized to longer wave lengths of light as well as to other physical agents. This may appear either as a local or reflex-like reaction. It seems logical to expect that the shorter wave length also should produce similar reactions in the body.

Warthin states that microscopic changes in the nuclei of cells can be demonstrated twelve hours after radiation, but admits that the final death of the cell is a gradual process lasting many days. According to Simpson, the visible effects occur after radium in from seven to fifteen days, may appear within from two to three days, and in some cases may be delayed for as long a period as four weeks. The inflammatory reaction corresponds with the visible effects of radiation, but the allergic symptoms should occur only after the cells are dead and absorption has begun to take place. This will occur after the visible effects of radiation have been present, or, in fact, where no surface effect is shown, if the dose administered is small. The general experience with radiation therapy is, I believe, that the time of appearance of the visible effects after radiation depends upon the wave length used, other factors being equal. The shorter the wave length the longer the time before visible reaction appears. Hirsch states the following in his book on roentgen therapy: "The secondary erythema manifests itself after a certain time, the so-called latent period. Its duration depends upon the radiosensitivity of the cells for normal tissues. *The period is longer for rays of short wave length.*" The gamma rays of radium, being the shortest in length, should produce the longest latent period of any light rays used. Our experience with gamma rays of radium is that the visible effect is frequently present one month after treatment, although perhaps beginning to subside. Necrosis of cells, that is, actual and complete death, should occur on the average about one month after radium, so from general experience the time interval is about what should be anticipated after gamma rays of radium are used.

No predisposition of this patient to allergic reactions is known, but the eosinophilia lasting over several years is suggestive. The sudden onset of symptoms, which suggests very strongly the so-called reflex-like reactions of Duke, seems suggestive of an allergic reaction to the short light wave lengths.

SUMMARY

The severe initial dose of radiation was sufficient as a sensitizing agent as the reaction was unusually severe. The suddenness of onset suggests the reflex-like or remote reaction described by Duke as characteristic of an allergic reaction. The small final doses of radium could hardly be expected in themselves to produce such dramatic sequelæ unless sensitization had already taken place.

The time intervals between the last two radium treatments and the onset of the symptoms were thirty and twenty-seven days, respectively, suggesting that the radiation was the most likely cause of the attacks. Moreover, the time interval between treatment and attack in each case was about that to be anticipated following gamma radiation from radium. It will be appreciated that the autolysis of necrotic cells will be perhaps somewhat later than the usual visible reaction after such radiation, as actual completion of the slow death of cells must take place first.

The angioneurotic edema present in both attacks seems well established. The widespread reaction, red, firm, itching, and swollen parts, dyspnea, temperature, vomiting, and prostration are characteristic of this condition.

This case seems a logical sequel to the light sensitization cases of Duke, except that this appears to have been produced by the shorter instead of the longer wave lengths. The case cited is not considered as a positively proved case of radiation sensitization, but it is so strongly suggestive of allergic reaction to light that it is presented in the hope of stimulating further observation and discussion.

BIBLIOGRAPHY

(1) Beck, Emil G.: Jour. Radiol., August, 1922, III, 301.
(2) Cooke, R. A.: Personal communication.
(3) de Courmelles, Foveau: Am. Jour. Electrother. and Radiol., March, 1924, XLII, 85.
(4) Denis, W., and Martin, Charles L., with assistance of Martha Aldrich: Am. Jour. Med. Sci., October, 1920, CLX, 555.
(5) Duke, W. W.: Personal communication. Allergy, Asthma, Hay Fever, Urticaria, and Allied Manifestations of Reactions. Second ed., C. V. Mosby Co., St. Louis, 1926.
(6) Hall, C. C., and Whipple, G. H.: Am. Jour. Med. Sci., April, 1919, CLVII, 453.
(7) Hirsch, Edwin F., and Petersen, A. J.: Jour. Am. Med. Assn., May 26, 1923, LXXX, 1505.
(8) Hirsch, I. Seth: The Principles and Practice of Roentgen Therapy. American X-ray Publishing Co., New York, 1925, p. 308.
(9) Golden, Ross: Arch. Int. Med., November, 1922, XXX, 629.
(10) Jüngling: Fortschr. a. d. Geb. d. Röntgenstr., 1924, 32 Kong., Heft I, 134-137.
(11) Lange: Jour. Am. Med. Assn., 1915, LXV, p. 1906.
(12) Lignac, P., and Devois, A.: Presse méd., April 2, 1924, XXXII, 292.
(13) Schmitz, Henry: Radiology, March, 1924, II, 137.
(14) Simpson, Frank Edward: Radium Therapy. C. V. Mosby Co., St. Louis, 1922.
(15) Tuffier: Bull. Acad. de Méd., Paris, June 17, 1924, XCI, 763.
(16) Warthin, Aldred Scott: Am. Jour. Med. Sci., January, 1914, CXLVII, 72.

DISCUSSION

Dr. Francis Carter Wood (New York): I was very much interested in Dr. Moore's report because I have had two cases which may illustrate the phenomenon. One was a woman who had had an extensive carcinoma of the breast which had been removed surgically, merely to get rid of a large mass in the hope that we might, by radiation afterwards, be able to somewhat control the return. After the first dose of X-ray, she developed a giant urticaria; the wheals were two inches—sometimes three inches—in diameter and hemorrhagic. They were stubborn in yielding to treatment. I refused to believe that this condition was connected with the X-ray. We gave her another dose and she had again, a few days later, an attack of giant urticaria with the same symptoms. In order to make a final test, thinking her mentality might have something to do with it, without saying anything I put a bandage on her chest with a radium needle carrying one milligram of radium, and left it over night. She had urticaria in three days' time. We obviously had to abandon treatment.

The second case was a woman with a mild perineal pruritus, who was subject to asthma. She was treated during the wintertime and her asthma was summer asthma, of the hay fever type. We gave her about half an erythema in the perineal region. She came back in a few days and said that it gave her an attack of asthma. She was radiated again and came down with another acute attack of asthma. She said she would try it once more, as her pruritus was much better. We radiated her a third time and she had a third attack of asthma. We kept in touch with her—she had no more asthma the rest of the winter. These three attacks were synchronized with three half-erythema doses in the peritoneal region. It must be that there is a small amount of fairly immediate destruction of tissue because with radiation some cells, especially lymphocytes, may disappear within twenty-four hours. Then the allergic condition appears in those who are highly sensitized.

I think this case reported by Dr. Moore is extremely suggestive. His dose was much smaller than mine. The patient was evidently not so highly sensitized as were these other two cases, but I think the phenomenon of radiation allergy exists, though, fortunately, it is extremely rare.

Dr. Rollin H. Stevens (Detroit): Dr. Moore's paper on radiosensitization was a very interesting report of a case the like of which I have not seen in my practice. When Dr. Moore wrote me about this case, I studied it from every angle and tried to find some other reason than the one mentioned for the symptoms, but I concluded that it was probably really an anaphylactic shock due to the autolysis of the malignant cells and absorption which would in all probability have taken place, as Dr. Moore says, about a month later.

We have many different kinds of protein absorbed at different times during the radiation treatment, and possibly some of the early symptoms which we get after radiation treatments, such as vomiting and diarrhea (the latter immediately after deep therapy of the abdomen) are due to some chemical change in the body fluids.

Of course you remember that we get a loss of leukocytes a short time after radiation —even by the time we get through giving the first exposure we note a diminution in the number of leukocytes. Something happens to them: just what is not clear. After a week or two they begin to return. In the four-week period we note other reactions, probably due to absorption of protein matter from disintegrated cells of one kind or another, and this may in sensitive cases result in anaphylactic shock.

Dr. Alden Williams (Grand Rapids, Mich.): I thought that Dr. Moore's paper was particularly well worked up and I am quite surprised to find that such a condition as he reports may be possible. I have had telephone messages from patients six weeks after radium treatment saying that they had had a pain in the back and they wondered if the radium I had used on their face a month and a half previously could be the cause of that pain. I think that perhaps we will have to be a little careful about talking about four-weeks-later radium anaphylaxis, or we will set our public to thinking that almost anything that happens to them, except an automobile accident, may be traceable back to our treatment.

AN INTRACRANIAL CALCIFICATION, PROBABLY OF CHOROID PLEXUS[1]

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BRAIN tumors are responsible for about 1 per cent of deaths (Ewing, 1), deaths which most often occur in early or middle adult life and are preceded by great suffering. It has been possible only within recent years to treat a few of these patients with success, a success which has been attained chiefly because of the earlier localization of the tumor.

Roentgenography has contributed much to the earlier and more accurate localization of brain tumor, through the works of Schüller, Sosman, Dandy, and many others. Any further knowledge which may strengthen or clarify the diagnosis seems desirable. This paper is concerned chiefly with the occurrence and localizing value of a radiographic shadow due to calcium deposits in the choroid plexuses of the lateral cerebral ventricles.

The normal gross anatomy and histology are fully described in most text-books (Fig. 1). Each of the ventricles contains a plexus —highly vascular, villous tufts, covered by epithelium (ectodermal) derived from the ependyma. They occupy a relatively small space within the ventricles, and are bathed by the ventricular fluid. They are attached to the ventricular wall by delicate laminæ which represent developmental infoldings of the pia-arachnoid (mesodermal) and which form a supporting meshwork for their many capillaries.

The choroid plexuses of the lateral ventricles, with which this paper is mainly concerned, are elongated structures, diverging slightly as they pass backward from each foramen of Monro. They lie on the floor of the body of the ventricle, and terminate a little beyond the junction of the inferior and posterior horns. The posterior extremity is expanded to a diameter of about one centimeter, called the glomus. The right and left glomus lie, one on each side of the sagittal plane, separated by a distance of about five centimeters. The glomus is the only part wherein calcification occurs in sufficient amount to produce an X-ray shadow. (The suprapineal portion of the plexus of the third ventricle may be an exception.) The pineal body, which more often casts a shadow, is exactly in the sagittal plane, about two centimeters in a frontal direction, midway between the right and left glomus.

The function of the choroid plexuses is to produce the cerebrospinal fluid. This they do, according to prevalent belief, not as secretory glands, but as semipermeable membranes (2). However, certain investigators believe the plexuses absorb the cerebrospinal fluid, while a minority believe they have nothing to do with the fluid (3, 4, 5).

Important as their function is generally conceded to be, it is somewhat striking that no disease or symptom-complex aside from tumor has been convincingly attributed to pathologic states limited to the plexuses. Yet regressive metamorphoses are so commonly present as to be considered "physiologic." These changes start in childhood, gradually increase with advancing years, becoming pronounced and characteristic in old age. They consist mainly of hyaline degeneration, connective tissue increase, and vascular occlusion. Vessels are not uncommonly found calcified (angioliths and phleboliths). Sclerotic connective tissue has been reported as partially ossified, though without calcium deposition. Hyaline concentric bodies, the origin of which is in some doubt, are of common occurrence. They are often calcified in whole or in part, and are sometimes present in extraordinary amounts. Probably these calcified concentric bodies

[1]Read before the Radiological Society of North America at the Fourteenth Annual Meeting, at Chicago, Dec. 3–7, 1928.

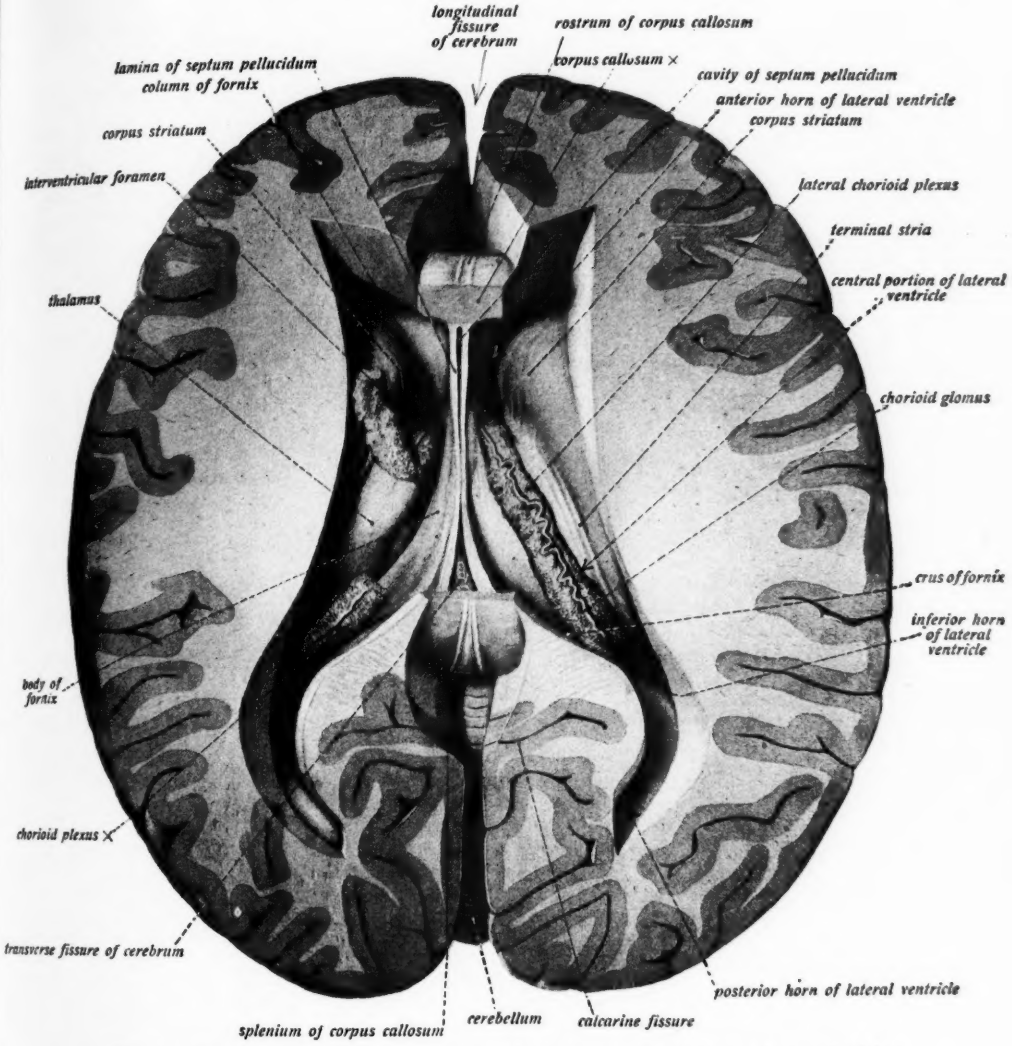

Fig. 1. Position and relations of chorioid plexuses of lateral cerebral ventricles. (From Sobatta and McMurrich, Atlas and Text Books of Human Anatomy, Vol. III. W. B. Saunders Co., 1909.)

(corpora arenacea, psammoma bodies, *sandkörper*, brain sand, etc.), with or without angioliths and phleboliths, are responsible for the X-ray shadows.

Several writers have dealt with the relationship between the pathology of the choroid plexus and various general, neurologic, and mental diseases. (For greater detail on this subject, as well as for more complete consideration of the pathology, the reader is referred to the bibliography which follows.) The general belief, based on postmortem findings, is that no clear relationship exists. This is by no means a unanimous opinion, however. As calcification in this structure is conceded to be an expression of regressive change, and is demonstrable by X-ray examination in a fairly high percentage of patients, as will be shown later in this article, the X-ray dem-

Fig. 2. Chorioid plexus shadows of density plus 4. The two shadows are exactly superimposed.

Fig. 3. Chorioid plexus shadows of density plus 4. The periphery of each glomus is more dense than the center. The two are not exactly superimposed.

onstration may afford a new means for selecting cases for antemortem investigation of the significance of these regressive changes.

Radiographic visualization of the two glomus shadows has been considered rare. It was probably first recognized by Schüller (26), although Stocking's English translation of Schüller's text (27) states that the calcification cannot be shown. It was mentioned and illustrated by Heuer and Dandy (28) in their important contribution in 1916, and has subsequently been mentioned by Ström (29), O'Sullivan (30), Vastine and Kinney (31), and Murphy (32).

The writer first noticed the shadows in 1926. They were well marked in the head films of a patient suspected of having brain tumor (Fig. 2). Being then unfamiliar with the shadow, a diagnosis of brain tumor with calcium deposit was made. The error was corrected by Dr. W. E. Dandy, to whom the patient was referred. Possibly there are other roentgenologists who, through unfamiliarity, might fall into the same error. This possibility constitutes one reason for presenting the findings which follow.

The material reviewed has been selected from the files of stereoscopic head films at the Riverside Hospital. Eighty-six cases have been considered technically satisfactory. All are white adults above the age of twenty years. It has been a surprise to find the choroid shadow demonstrated twenty-four times (about 28 per cent) in this series of 86: once exceptionally well; six times very well; eleven times less well but clearly, and six times faintly. In general, the more plainly visible shadows occur in the older patients, and in those with the most pronounced pineal shadow, although there are several exceptions. The average age of patients with choroid shadow was forty-eight and three-tenths years; the youngest twenty-five (plus 2); the oldest seventy-six (plus 2). Eighty-seven and five-tenths per cent have a demonstrable pineal shadow. Sixty-two and five-tenths per cent were males, 37.5 per cent females. Of 62 cases not showing the choroid shadow, the average age was thirty-five and

Fig. 4. Chorioid plus shadow of density plus 3, showing relation to pineal.

Fig. 5. Oblique antero-posterior projection, retouched to show triangular relation of the pineal and the two glomus shadows.

five-tenths years; the youngest twenty; the oldest seventy-one. Sixty and six-tenths per cent had a demonstrable pineal. Fifty per cent were males and 50 per cent females. For those patients showing the choroid shadow there was no correlation between the clinical condition and the occurrence of the shadow.

The technical factors used in these 86 cases were nearly always as follows: Curved Bucky diaphragm; 10 milliampere radiator type Coolidge tube; 4 to 5 inches spark gap; 30 inches target-film distance; double intensifying screens; "superspeed" film; exposure time varying between 15 and 25 seconds; stereoscopic right and left lateral projections, and occasionally stereoscopic oblique antero-posterior (Towne position) projections. These factors, it is believed, bring out a maximum of detail, a belief which is confirmed to some extent by a series of 62 head examinations made at the Duval County Hospital, where a flat Bucky diaphragm, 30 ma. tube, and 25 inch distance are in use. In this series there were but three cases showing the choroid shadows. Most of these patients were negroes.

The unexpected percentage, 28 per cent, of cases showing the two shadows, naturally raised the question: Are the shadows actually produced by the choroid plexuses? Their identity was established as follows:

The brain of a negro man, age thirty-nine, was obtained at autopsy. Stereoscopic films of the removed brain showed two shadows, presumably of the choroid plexuses, in their characteristic positions. The ventricles were then opened and the plexuses removed. Films made thereafter showed the pineal shadow, but not the two shadows in question. These plexuses were examined microscopically and numerous calcified concentric bodies found.

When the shadow is well marked it is somewhat oval, about one centimeter in diameter, without very sharply defined borders. The density is not uniform, the shadow giving the impression of many superimposed small dots and small curved shadows, with here and there an area without shadow

increase. When less well marked (plus one and plus two) the shadow is composed of only a few scattered dots and short curves, sometimes so indistinct as to be overlooked, unless one is searching for them. Stereoscopic vision of lateral projections resolves the superimposed glomus shadows into two, separated by a considerable distance. In oblique antero-posterior views the fainter shadows are not discernible, but in those which are designated plus three and plus four, the two shadows are seen exactly opposite each other, one on each side of the midline, and separated by about four or five centimeters. In this view, when the pineal is also visualized, the three shadows stand at the angles of an isosceles triangle, the pineal at the obtuse apex anteriorly, the two choroid shadows at the angles of the base posteriorly (Fig. 5).

Naffziger (33) and Vastine and Kinney (31) have called attention to the localizing value of the shift of the pineal shadow in a direction away from the site of a brain tumor. Murphy (32) has emphasized the same significance for the shift of the less common calcareous bodies in the falx. It is the writer's belief that since the choroid shadows are demonstrable in about one out of four or five adults, since they occupy normally a fixed bilateral and symmetrical position, and since their normal position in relation to the pineal shadow is characteristic it is a justifiable conclusion that any definite displacement should be apparent and have a diagnostic value comparable with that accepted for the shift of the pineal and falx.

None of the patients in the writer's series have had certified brain tumor. However, it has been felt that the presence of these shadows in a normal position, in the few cases suspected of brain tumor, has added valuable evidence against the presence of tumor.

CONCLUSIONS

1. Pathologic changes of a regressive character, often with calcification, are of common occurrence in the choroid plexuses, particularly the glomus, and have been well studied by pathologists.

2. Calcium deposits in the glomus are in sufficient amount to cast a recognizable shadow on the X-ray film in a rather large percentage of adults, 28 per cent in 86 cases studied.

3. Demonstration of this calcification suggests that postmortem investigations as to the significance of regressive changes in the choroid might be supplemented by antemortem studies of selected cases.

4. At present the shadow should be considered normal and not confused with pathologic intracranial calcification.

5. The fixed normal position of the choroid shadows in relation to each other and the pineal shadow should give them the same significance in the localization of brain tumor as the midline shadows of the pineal and deposits in the falx.

BIBLIOGRAPHY

(1) Ewing, James: Neoplastic Diseases. W. B. Saunders Co., Philadelphia, 1928.
(2) The Choroid Plexus and the Cerebrospinal Fluid (Current Comment). Jour. Am. Med. Assn., March 10, 1928, XC, 771.
(3) Buzzard, E. F., and Greenfield, J. G.: Pathology of the Nervous System. Paul B. Hoeber, Inc., New York, 1927.
(4) Davis, Loyal E.: A Physio-pathologic Study of the Choroid Plexus, with the Report of a Case of Villous Hypertrophy. Jour. Med. Research, September, 1924, XLIV, 521.
(5) Hassin, George B.: Effect of Organic Brain and Spinal Cord Changes on Subarachnoid Space, Choroid Plexus, and Cerebrospinal Fluid. Arch. Neurol. and Psychiat., October, 1925, XIV, 468.
(6) Van Ghert, J. M. E.: De Plexubus Choroideis. Trajecti ad Rhenum, 1837. (Probably the oldest article in Surgeon General's Library; not available to writer.)
(7) Harless, E.: Ueber die Ablagerungen Anorganischer Substanzen auf dem Plexus Choroideus. Müller's Arch. f. Anat., u. Wissensch. Med., Berlin, 1845, 354.
(8) Quain, R.: Calculous Particles from the Choroid Plexus. Trans. Path. Soc., London, 1850-51, III, 45.
(9) Haeckel, E.: The Normal and Pathologic Anatomy of the Choroid Plexus (in German). Virchow's Archives, 1859, XVI, 253.
(10) Meyer, S.: Ueber die Struktur, das Vorkommen und die Entstehung der Sandkörper. Virchow's Archives, 1896, CXLIII, 196.

(11) FINDLAY, JOHN W.: The Choroid Plexuses of the Lateral Ventricles of the Brain: Their Histology, Normal and Pathological (in Relation Specially to Insanity). Brain, 1899, XXII, 161.

(12) CORNIL, A. V., and RANVIER, L.: Manuel d' histologie pathologique, Paris. 1901, I, 96, 97.

(13) TSIMINAKIS, C.: Zur Pathologischen Histologie der Plexus Chorioidei. Wiener klin. Wchnschr., Sept. 10, 1903, XVI, 1051.

(14) PELLIZZI, B.: Experimentelle histologische Untersuchungen über die Plexus chorioidei (adergeflechte). Folia neuro-biol., Leipzig, 1910-11, V, 305.

(15) ASKANAZY, M.: Zur Physiologie und Pathologie der Plexus Chorioidei. Verhandl. d. deutsch. path. Gesellsch., 1914, XVII, 85.

(16) CUSHING, HARVEY, and WEED, LEWIS H.: Studies on the Cerebrospinal Fluid and Its Pathway. No. IX. Calcareous and Osseous Deposits in the Arachnoidea. Johns Hopkins Hosp. Bull., November, 1915, XXVI, 367.

(17) WÜLLENWEBER, GERHARD: Ueber die Funktion des Plexus Chorioideus und die Entstehung des Hydrocephalus Internus. Ztschr. f. d. ges. Neurol. u. Psychiat., 1924, LXXXVIII, 208.

(18) BOUDET, G., and CLUNET, J.: Contribution à l'étude des tumeurs, épithéliales primitives de l'encéphale, développées aux dépens des formations épendymaires et particuliérement des plexus choroides. Arch. de méd. expér. et d'anat. path., 1910, XXII, 379.

(19) CIACCIO, C., and SCAGLIONE, S.: Beitrag zur Cellulären Physiopathologie der Plexus Chorioidei. Beitr. z. pathologisch. anat. u. z. allg., Path., 1912, LV, 131.

(20) SAITO, MAKOTO: Zur Pathologie des Plexus Chorioideus (Hydrocephalus, Tumor, Meningitis, Encephalitis). Arb. a. d. Neurol. Inst. a. d. Wien. Univ., September, 1921, XXIII, 49.

(21) TANNENBERG, JOSEPH: Ueber Plexusveränderungen und ihre Beziehungen zur Uraemie. Centralbl. f. allg. Path. u. pathol. Anat., Dec. 1, 1921, XXXII, 169.

(22) MOROWOKA, T.: Microscopical Examination of Choroid Plexus in General Paralysis of Insane, and Other Forms of Mental Disease. Proc. Roy. Soc. Med., Sect. Psychiat., London, August, 1921, XIV, 23.

(23) KITABAYASHI, S.: Choroid Plexuses in Organic Disease of the Brain and in Schizophrenia. Jour. Nerv. and Mental Dis., July, 1922, LVI, 21.

(24) TAFT, A. E.: A Note on the Pathology of the Choroid Plexus in General Paralysis. Arch. Neurol. and Psychiat., February, 1922, VII, 177.

(25) FERRARO, A.: Lo stato odierno delle nostre conoscenze sulla struttura e funzione dei plessi coroidei. Il Cervello. 1925, IV, 159.

(26) SCHÜLLER, A.: Quoted by Ström. See Reference 29.

(27) SCHÜLLER, ARTHUR, Trans. by Stocking, Fred F.: Roentgen Diagnosis of Diseases of the Head. C. V. Mosby Co., St. Louis, Mo., 1918.

(28) HEUER, GEORGE J., and DANDY, WALTER E.: Roentgenography in the Localization of Brain Tumor, Based upon a Series of One Hundred Consecutive Cases. Bull. Johns Hopkins Hosp., November, 1916, XXVI, 311.

(29) STRÖM, S.: Ueber die Röntgendiagnostik intrakranieller Verkalkungen. Fortschr. a. d. Geb. d. Röntgenstr., February, 1921, XXVII, 577.

(30) O'SULLIVAN, J.: Some Rarer Intracranial Calcifications and Ossifications. Brit. Jour. Radiol., August, 1925, XXX, 295.

(31) VASTINE, J. H., and KINNEY, K. K.: The Pineal Shadow as an Aid in the Localization of Brain Tumors. Amer. Jour. Roentgenol. and Rad. Ther., March, 1927, XVII, 320.

(32) MURPHY, JOHN T.: Intracranial Calcifications. RADIOLOGY, September, 1928, XI, 213.

(33) NAFFZIGER, H. C.: A Method for the Localization of Brain Tumors: The Pineal Shift. Surg., Gynecol. and Obst., April, 1925, XL, 481.

FURTHER OBSERVATIONS ON THE DIRECT ROENTGENOLOGIC SIGNS OF GASTROJEJUNAL AND JEJUNAL ULCER[1]

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THE diagnosis of gastrojejunal or jejunal ulcer is one of the most perplexing that the roentgenologist is called on to make. The examination involves structures that have been changed by surgical intervention, and for this reason atypical operations may complicate the usual appearance and suggest a lesion when none is present. In other instances there may be doubt as to the presence of a gastro-enterostomy opening. Nevertheless, reasonably definite roentgenologic criteria for the normal and abnormal anastomosis can be established.

Moynihan and Eusterman have observed that the majority of surgical failures following gastro-enterostomy are caused by the construction of an anastomosis in the absence of intrinsic disease of the stomach or duodenum. For this reason the demonstration by the roentgenologist of normal structures is quite as important as the diagnosis of post-operative disease.

Fig. 1. Normal gastro-enterostomy opening. The continuity of the gastric rugæ and jejunal markings at the anastomosis is shown.

Fig. 2. Ulcer crater in efferent loop of jejunum accompanied by deformity of the jejunum.

Pathologically, gastrojejunal and jejunal ulcers simulate in form the usual types of gastric ulcer, that is, mucous, penetrating, and perforating. The most common is the penetrating type, which is usually found in the suture line at the stoma, or wholly within the jejunum. The majority of the latter occur in the efferent loop and may be situated as far as 15 cm. from the anastomosis.

[1]Read before the Radiological Society of North America, at the Fifteenth Annual Meeting, at Toronto, Dec. 2–6, 1929.

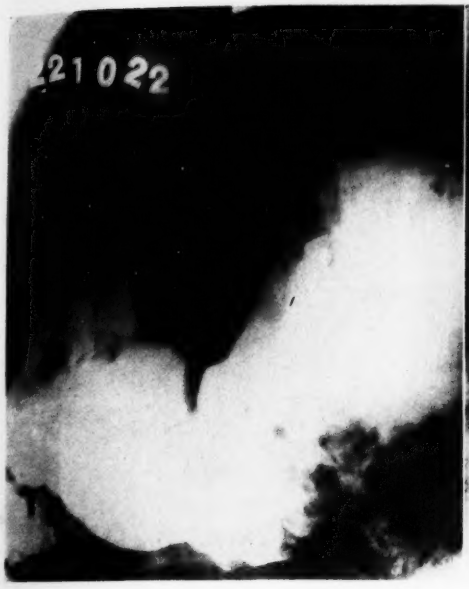

Fig. 3. Gastrojejunal ulcer producing a characteristic puckered appearance of the stomach at the site of the anastomosis. The contiguous jejunum is also deformed.

Fig. 4. Tubular appearance at stoma produced by inflammatory reaction accompanying a gastrojejunal ulcer. The obliteration of the markings of the gastric rugæ and jejunum may be noted.

Multiple ulcers are not uncommon. Jejunal ulceration is somewhat more common than ulceration at the stoma or ulceration on the gastric side. In a series observed at operation at The Mayo Clinic, sixty-one cases of jejunal ulceration were found as compared with forty-eight cases of stomal ulceration. In addition, gastrojejunitis without evidence of actual ulceration, as described by Moore and Marquis, was observed in eight cases of this series.

Interpretation of the signs of post-operative gastrojejunal or jejunal ulceration presupposes an understanding of the characteristics of the normal gastro-enterostomy opening (Fig. 1). These may present slight variations, depending on the technic of the surgeon, but as a general rule the following conditions denote a normal anastomosis: (1) the meal passes freely through the stoma; (2) there is no gastric residue; (3) the duodenal and jejunal loops are not dilated; (4) the stomach is commonly smaller than is usual without gastro-enterostomy; (5) gastric peristalsis is not overactive; (6) the stomach and jejunum in the region of the anastomosis are flexible, moderately mobile, and not deformed; (7) the markings of the gastric rugæ and valvulæ conniventes are maintained and are contiguous with each other at the stoma, and (8) the loops of jejunum are not deformed by localized or diffuse irregularity.

The direct roentgenologic signs which individually permit a positive diagnosis of gastrojejunal or jejunal ulceration are: (1) the presence of an ulcer niche; (2) persistent deformity of the stomach, stoma, or jejunum; (3) the presence of a gastrojejunocolic fistula, and (4) closure of the stoma. These conditions are best shown during the fluoroscopic examination with the patient in the upright position. The stomach should be empty and the examination should be made after only a swallow or two of the opaque meal. If all of the meal is taken at once its

Fig. 5. Localized narrowing in jejunum adjacent to stoma, with obliteration of jejunal folds in affected area. Jejunal ulcer.

Fig. 6. Diffuse narrowing of efferent loop of jejunum, with obliteration of jejunal folds. Stomach normal. Jejunal ulcer.

rapid exit through the stoma, with filling of the overlying loops of jejunum, will hopelessly obscure the field. As the first portion of barium enters the stomach its descent is checked by approximating the gastric walls with pressure by the gloved right hand. This permits complete inspection of the gastric rugæ on both walls, and as the hand is moved downward, the gastro-enterostomy opening and contiguous gastric surfaces may be seen. At this point the pressure of the hand is lessened and the barium is allowed to enter the jejunum, at which time the direction of the loop can be observed. Palpation is then resumed over the jejunal area and the site of the anastomosis. During these procedures the flexibility and degree of fixation of the various parts are noted. After satisfactory inspection of the stoma and the jejunum, it is usually desirable to give the remainder of the opaque meal and to determine the patency of the pylorus and the outline of the duodenal bulb and loop. In the presence of rapid emptying through the gastro-enterostomy opening, it is often impossible to express barium through the pylorus, since manual pressure only serves to hasten its exit through the anastomosis. Occasionally it may be possible to block the gastro-enterostomy opening with pressure by the left hand and then manipulate the barium through the pylorus with the right hand.

The significance and frequency of a niche or crater in the jejunum or stoma as a positive sign of ulceration is often underestimated. It represents irrefragable evidence of disease and should be sought for in each instance. It is my impression that a niche may be seen in about 60 per cent of cases. The majority are found in the jejunum, nearly always in the efferent loop, and sometimes as far as 15 cm. from the stoma. The usual shadow of the niche is slightly less than 1 cm. in diameter and projects from the lateral border of the efferent loop, frequently close to the stomach (Fig. 2). Scott has stated that the majority of gastrojejunal ulcers are shown in the mesial gastrojejunal angle, which is formed by the greater curvature of the stomach and the mesial border of the efferent jejunal loop. This is an interesting difference in observation, for in

my experience most of the niche shadows are found within or below the lateral gastrojejunal angle, regardless of whether the loop is made to the left or to the right. The niche invariably fills after the first swallow of barium, and will stand out as a round shadow of increased density within the stoma or as a projection from the contour of the jejunum. It frequently resembles in appearance one of the bud-like diverticula found in the colon. The niche must be distinguished from flecks of barium retained by gastric rugæ or jejunal folds. The latter can be effaced by pressure and manipulation, but the shadow of a niche will remain the same and will often become more pronounced when pressure is made over it. If the crater should empty, it will reappear at the same point, and, of course, can be found at a second examination. A niche is always accompanied by deformity of the jejunum near the site of ulceration. Multiple ulcers are not uncommon, but it is rare to observe more than one crater in the same patient.

Deformity of the stomach, stoma, or jejunum produced by the associated inflammatory reaction is the most common change accompanying a gastrojejunal or jejunal ulcer. The deformity of the stomach usually seen with ulceration at the stoma appears as puckering of the gastric contour about the site of the opening, with deformity of the rugæ (Fig. 3). In many cases in which the stomach empties rapidly, the stoma and contiguous portion of the jejunum have a tubular or funnel-like appearance, indicating inflammatory induration (Fig. 4). In such cases the continuity of the gastric rugæ and jejunal markings is interrupted in the involved area. When the lesion is wholly within the jejunum, deformity of the stomach may be absent.

Deformity of the jejunum, which is manifest as persistent narrowing, with retraction or irregularity of the normal outline, may be localized or diffuse (Figs. 5 and 6). It occurs most commonly in cases of jejunal ulcer but may be associated in a lesser degree with ulceration at the stoma. Within the deformed area the normal markings of the valvulæ conniventes of the jejunum are obliterated, due to the existing inflammatory reaction. This is a significant point of distinction from deformities due to adhesions. Localized narrowing may involve only a small area and is easily overlooked. A significant deformity will persist throughout the examination and be evident at a subsequent observation. An associated ulcer niche may or may not be demonstrable.

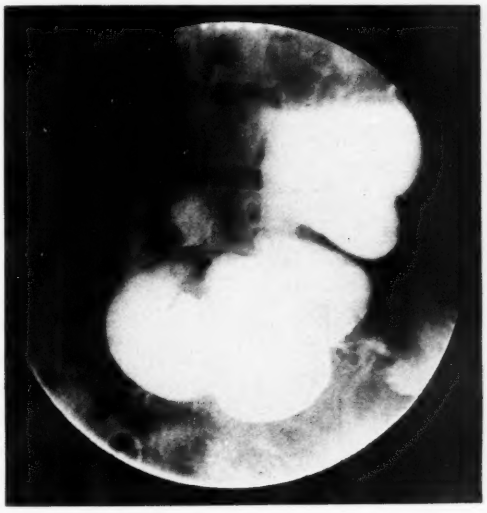

Fig. 7. Obstruction at the site of gastro-enterostomy, with nearly complete occlusion of stoma. Dilatation of stomach and hyperperistalsis may be noted.

In the absence of a malignant lesion, the presence of a gastrojejunocolic fistula is evidence of preceding jejunal or gastrojejunal ulceration, whether or not additional signs are present. Verbrugge, in a review of the cases of gastrojejunal ulcer at The Mayo Clinic, found that gastrojejunocolic fistula had developed in 11 per cent. Because of the high incidence of this complication and the risk attending the operation for its cure, the early recognition of the causative lesion is of considerable significance. The barium

meal should not be relied on to show a fistula, since it frequently can be discerned only by means of the opaque enema.

Complete occlusion of a previously functioning gastro-enterostomy opening in the absence of malignant disease is *prima facie* evidence of gastrojejunal ulceration (Fig. 7). It is unlikely that a normally functioning stoma will close of itself, and the experience of many surgeons supports this. Some patients are not certain whether or not gastro-enterostomy has been done, and in such instances the roentgenologist may overlook an occluded stoma. At this time the indirect signs incident to inadequate gastric drainage may suggest occlusion of a previous anastomosis. In occasional cases the inflammatory process producing occlusion of the stoma also causes obstruction of the jejunal loops.

Since a positive diagnosis is based on evidence of malfunction or the demonstration of abnormality in the outline of the stomach, stoma, or jejunum, the examiner must assume that in the beginning the gastro-enterostomy opening was anatomically correct and functioning properly. A knowledge of the surgical technic employed in the particular case is of considerable assistance.

Mechanical conditions that may mislead the examiner consist of a stoma made too small originally, a jejunal loop that is too short, adhesions, and herniation of the jejunal loop through the opening in the mesocolon. The last condition is rare since the practice of stitching the edges of the opening in the mesocolon to the stomach has been adopted. The other conditions can be differentiated by the flexibility of the parts and the presence of normal gastric rugæ and jejunal markings. Their outlines may be distorted but they will not be obliterated as is the case in jejunal ulceration.

The foregoing signs have been the basis for the roentgenologic diagnosis of jejunal and gastrojejunal ulcer at The Mayo Clinic for a considerable time. The progressive improvements in fluoroscopic technic, increasing familiarity with the niche shadow, and a better appreciation of the pathologic changes and the complications of these lesions are reflected in the increased percentage of diagnostic successes. In the last two years a positive roentgenologic diagnosis of gastrojejunal ulcer has been confirmed by the surgeon in 90 per cent of cases, as compared with 74 per cent ten years ago.

BIBLIOGRAPHY

(1) Eusterman, G. B.: A Clinical Study of Eighty-three Gastrojejunal Ulcers; Diagnosis Verified at Operation. Minn. Med., 1920, III, 517-524.

(2) Moore, A. B., and Marquis, W. J.: The Roentgenologic Diagnosis of Gastrojejunal Ulcer. Am. Jour. Roentgenol. and Rad. Ther., 1925, XIV, 432-435.

(3) Moynihan, Berkeley: Disappointments after Gastro-enterostomy. Brit. Med. Jour., 1919, II, 33-36.

(4) Scott, S. G.: Secondary Jejunal Ulcers and Their Radiological Diagnosis. Lancet, 1926, II, 222-224.

(5) Verbrugge, Jean: Gastrojejunocolic Fistulas. Arch. Surg., 1925, XI, 790-808.

DISCUSSION

Dr. L. T. Le Wald (New York City): I would like to ask Dr. Camp what they did in the case in which there had been two operations, each followed by marginal ulcer.

Dr. Hans A. Jarre (Detroit, Mich.): This subject has been one of considerable importance in our private practice for years. It is closely related, of course, to the etiology of peptic ulcer and also to the question: What does the surgeon accomplish in the treatment of ulcer? I cannot discuss these questions here at length, but we should like at least to hear, as Dr. Le Wald has pointed out, what the Mayo Clinic does in those unfortunate cases of peptic ulcer which recur regardless of the type and extension of the resection and the type of former treatment.

Furthermore, I want to make a plea here for your support in regard to investigations, striving for a better contrast medium for

intestinal examinations. It is desirable that we pay more attention to the configuration and structure as well as the function of the mucosa. For such refined studies we need to replace the entirely non-transparent barium suspension by a semi-opaque colloid, electrically so charged that it will precipitate on the mucosa as a thin adherent coating. It is evident from the literature that experiments to find such a colloid are under way in Europe. We hope that at some future time we may be able to submit for your approval such an improved colloidal contrast medium for gastro-intestinal studies. Then the term "gastritis," which at present I dislike so much, may be resurrected, with a proper meaning.

DR. JOHN D. CAMP (closing): The patient that Dr. Le Wald referred to returned with a recurrent ulcer, and he was not operated on again. There was not much of the stomach left. The discussants have brought up the old question of the proper method of treating ulcers. This seems to be a matter for the surgeons and medical men to decide, and I prefer not to get mixed up in it.

ECONOMIC PROBLEMS OF THE X-RAY LABORATORY[1]

By PRESTON M. HICKEY, A.B., M.D., ANN ARBOR, MICHIGAN

WITH the discovery that X-ray waves would change the silver in a photographic emulsion, the users of X-ray equipment naturally made use of the photographic plates which were commercially available. The size and shape of these photographic plates had been determined from the pictorial standpoint for landscapes and groups. With the exception of the special oblong plates which were made for Dr. Charles Lester Leonard for kidney examinations, we can find no record that any attempt has been made to study the requirements of the roentgenologist in regard to the sizes and shapes of X-ray plates and X-ray films appropriate for diagnosis.

As a result there is at the present time a great economic waste in X-ray laboratories, a situation which it is one of the purposes of the present paper to discuss. A presentation of the problem seems quite timely, inasmuch as the manufacturers are at present engaged in studying the situation in regard to photographic films and photographic paper. Recently there have been many changes in the size of films and paper calculated to result in a standardization which will be an economic gain to the professional photographer.

In every X-ray examination of the adult chest the present size of 14 by 17 film is the one which is universally used. A careful study of a large number of chest films shows a waste due to the fact that the lower part of the average chest film is blank. The German economists have recognized this waste and have suggested making two exposures on the present 14 by 17 film, using a mat which will allow one of the exposures to be made of the apices, while the rest of the film can be used according to our present ideas. Such a system of double exposures, however, is inconvenient and oftentimes not needed. The greater number of chest examinations could be made on a 14 by 14 film.

The writer has calculated that in a laboratory where, say, 6,600 chest examinations are made during the year, using 13,200 14 by 17 films, there is an economic loss of considerable moment. If acetate of cellulose films are used, with a trade discount of 20 per cent, which may be taken as the average trade discount allowed to many of the laboratories, the money value of the 42 square inches of unused film is $1,716. If, in these 13,200 films, nitrate of cellulose is employed, with an average trade discount of 20 per cent, the value of the 42 square inches of film which is wasted is $1,452. In other words, in an X-ray laboratory where 6,000 chest examinations are made a year, there would be a saving of $1,700 a year if 14 by 14 films were used in place of 14 by 17. There would be a corresponding saving in developer and fixing bath. This is an economic waste which goes on year after year and on a ten-year basis the loss would, of course, be about $17,000 —money which should be diverted from the commercial trade to the treasury of the hospital or laboratory.

Another economic loss is found in the average X-ray examination of the adult spine. As the demands of the orthopedic surgeons become more insistent for X-ray examinations to include the entire spine, the problem becomes more acute. In the X-ray examination of the lumbar and thoracic spine, we usually make use of the 14 by 17 films. These are pictorially quite gratifying, but,

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2–6, 1929.

from a diagnostic standpoint, a narrower film could be employed. It is our firm conviction that a film one-half the width of the present size is quite sufficient for spinal diagnosis. Therefore, if we are using two 14 by 17 films for the antero-posterior projection of the spine and two 14 by 17 films for the lateral projection of the spine, we are using twice as much film space as is necessary.

Coming down to a concrete basis, in a hospital where the spine examinations number some two thousand a year it follows that with the economic loss of one-half of four films of the 14 by 17 size, the following interesting figures develop. On each case there would be a loss of two 14 by 17 films. If one is using acetate of cellulose films at $0.75 apiece, that means a loss of $1.50 on each case. On 2,000 cases a year this would amount to $3,000. If the nitrate of cellulose films are used at an average cost of $0.65 apiece, the yearly waste amounts to $2,600. On a ten-year basis this would amount to the tidy sum of at least $25,000. In addition, one must always consider the saving in developer and fixing bath. If a large laboratory loses $1,500 on chest films and $2,500 on its spine films, it has a yearly loss of $4,000, and a ten-year loss of $40,000.

We can find the same lack of economy to a less extent in the use of 14 by 17 films in the examination of the femur. When one considers that the extremity films are usually made on unsuitable sizes, one might say that the waste becomes even greater than we have already figured. The present 8½ by 14 size was a mistake in the first place and is quite unsatisfactory.

Another point is the saving which would follow in the size of the intensifying screens, the cost of which is at the present time a considerable item in every laboratory. If there was a film of appropriate size for use in many of these examinations, the reduction in the annual cost of intensifying screens would result in a very considerable saving.

A great time loss occurs in laboratories where there are several X-ray machines of different types. The automobile manufacturers have finally come together and agreed on a standard gear shift which simplifies the automobile from the driver's standpoint. We see no reason why the manufacturers of X-ray machines should not get together and, in consultation with the Bureau of Standards, agree upon a standard control stand. I do not think there is any argument about the fact that consultation would evolve a control stand which could be adopted, with elimination of many arbitrary scales at present found on many switchboards, and which are confusing and time-consuming.

There is at present a lack of uniformity in the size and thickness of the cassettes which are manufactured by different companies. Some of the manufacturers are so shortsighted as to build the dimensions of some of the pieces of equipment so that cassettes of arbitrary sizes have to be used. We feel that the Bureau of Standards should, after consultation with the manufacturers, put forth a standard for sizes of cassettes. This would certainly be a source of great gratification and saving to the long-suffering buyers, who are so helpless.

Another lesson which could be taken from the automobile manufacturers is that their engineers have agreed on a standardization of nuts and screws which has resulted in great simplification in the manufacture of automobiles.

In talking with many of the service men of different X-ray companies, one realizes that a standardization of the small parts of various items of X-ray equipment could be made, with a great saving in the cost of manufacture and in the cost of service.

The writer would like to call attention to

the advantage of salvage of the silver in the depleted fixing baths. The silver can be precipitated very simply without any added complication in the routine of the dark room, and the precipitated silver can be sent to one of the reclaiming companies, that charge only a moderate percentage for saving the silver.

We would like to speak also of the uneconomic and inconvenient method of lighting fluoroscopic rooms and dark rooms. The average dark room is too dark for efficient work: the use of safe lights properly tested would give much greater illumination. Much of the wear and tear on intensifying screens and the scratching of films is caused by the dark room technician working with insufficient illumination. The method of lighting fluoroscopic rooms is also usually rather antiquated. We rely on a small ceiling light which gives no illumination where illumination is desired. When the patient comes into a dark fluoroscopic room he walks with timidity. The illumination of the fluoroscopic room should be diverted from the ceiling, where it does very little good, to the floor, so that the patient can see where he is walking. A careful study of the illumination of moving picture theaters might add much to the convenience of the patients and personnel in fluoroscopic rooms.

We would like to call attention also to the simplification of X-ray reports in laboratories. At the present time in many laboratories there is a great waste of time and paper in writing out the elaborate descriptions of normal findings. These could be filled in on suitably printed blanks and a great saving in reports could be made.

A comment upon this paper as presented so far would be that it is chiefly destructive criticism. We feel, however, that a constructive note should be added. It is suggested that representatives appointed from the various national X-ray societies should work in accord with the Bureau of Standards in Washington and with a committee from the X-ray manufacturers, to devise a program which will eliminate some of the present waste in X-ray laboratories.

DISCUSSION

DR. WILLIAM J. CASSIDY (Detroit): We have standardized everything around the hospital but the equipment which is in daily use. Inasmuch as 80 per cent of our time in the hospital is spent under brilliant illumination, why do we try to work with instruments which we can hardly see? Everything is polished up so bright, we have to focus with such sharp tension, that we are working under high tension at all times. Watch the average ophthalmologist try to do an advancement; he is dodging back and forth, trying to find a beautifully polished *bright* needle. Watch the roentgenologist with his beautifully polished centering rod. Most of your cassettes are brightly polished, reflecting light, blinding you all the time. The general practitioner, with his stethoscope, is in the same boat, and the whole group of practitioners of medicine and surgery is in very much the same position in regard to all the equipment in use. It is because someone three or four thousand years ago designed it, and we forget to change it. That is just as true in one department as another, and the sooner we realize it and try to standardize some of the equipment we are using every day and make it more useful to the man operating rather than a fit object for a showcase, the better.

DR. GEORGE E. PFAHLER (Philadelphia): We all believe in economy and we all believe in standardization, so far as it is economy, but we must not forget that standardization very often stifles progress, and when we settle down to some particular thing, it stops the next man from suggesting something new that he believes is better. Now,

for example, the illustrations that have been thrown on the screen. I make my chest examinations always with the 17 inch crosswise. That takes in not only the full chest, just reaching the curve of the diaphragm or covering the curve of the diaphragm, but also the shoulders—and very frequently you get information with regard to the axilla and shoulders which is of value. With regard to the spine—for at least fifteen years I have been taking two spine views on one 14 by 17 film, which just fills it up nicely. In examinations of the entire femur, I take two on one, either two of the same femur in different positions or the two sides, that is, the two femora on the same film. I do not believe that we need to pay too much attention to this question of films. I think the question of economizing our own time and economy of the professional time in the X-ray laboratories is of very much greater importance than the economy of the materials, with which the authorities are already annoying us enough, and I believe that we ought to be a little bit careful before we go wild on this question of economy of materials.

DR. HICKEY (closing): I have three slides which I neglected to show. One shows the average chest on a 14 by 17 film, and the three inches at the bottom which are not used—that space is now wasted on every one of the chest films you ordinarily make. Next you have a 14 by 17 film used for examination of the lumbar spine. The space between the two white lines is 7 inches wide—amply sufficient to display all the structure of that spine. Most of the space outside of the white line is simply waste film. Every once in a while we want to use a 14 by 17 film for the femur because the other films are not long enough—and we have a beautiful white space outside these lines which is simply waste film. So we go on year after year buying films that we do not use for diagnostic purposes, and putting up with them. We do not seem to have the "intestinal fortitude" to tell people what we want.

THE WORK OF THE COMMITTEE ON THE COST OF MEDICAL CARE[1]

By ARTHUR C. CHRISTIE, M.D., WASHINGTON, D. C.

THE Committee on the Cost of Medical Care was created a little over two years ago to study the causes underlying an apparently widespread dissatisfaction with the present system. This dissatisfaction is evidenced by complaint on the part of the public that adequate medical care is beyond the means of a large percentage of our population not in the charity class, and also on the part of physicians that their average incomes are not sufficient.

It is generally admitted both within and without the medical profession that the question is an important one, for which a solution must be sought. It is also admitted that the task of finding the proper and adequate solution is a difficult one, and that any solution offered should be based upon a careful consideration of all the underlying facts. It was with this in mind that the Committee was organized to represent every class which may be affected by any proposed changes in the present system. It now has forty-six members, fourteen of whom are private practitioners of medicine, six are engaged in public health work, nine are representatives of hospitals, nursing, dentistry and various special interests; five are economists, and twelve represent the general public. The vital interest of the medical profession in the entire problem of investigation and in any proposed solutions is recognized by the Committee. The profession is represented not only by the fourteen medical practitioners mentioned above, but by twenty-three other members of the profession who are in public health work, superintendents of hospitals, deans of medical colleges and in various other administrative positions in institutions.

The American Medical Association is represented by its President and its Secretary. The Chairman of the Committee is the Hon. Ray Lyman Wilbur, Secretary of the Interior in President Hoover's Cabinet and formerly President of the American Medical Association.

Under the direction of this widely representative Committee a full-time Research Staff is carrying out the projected studies. Dr. Harry H. Moore, author of the well-known book, "American Medicine and the People's Health," is the Director of Study and head of the Research Staff. The Staff is made up at present of six persons, who were carefully chosen for their training and experience along various lines. One is head of a department of sociology; one an associate professor of public health; one an instructor in economics; one an executive secretary of a western city club engaged in municipal surveys, and one is a statistician.

The program of the Committee was adopted after detailed study, on Feb. 13, 1928, and, with a few later additions, contemplates approximately twenty-eight separate studies. Eight of these are concerned with "preliminary surveys of data showing the extent of disease and disability requiring medical services and of general existing facilities for dealing with these conditions." Eleven are studies on the cost to the family of medical services and the return accruing to the physician and other agents furnishing such service. Nine are "analyses of specially organized facilities for medical care now serving particular groups of the population." The program is laid out for a five-year period, which, in view of the impor-

[1]This is not an official publication of the Committee on the Cost of Medical Care. Any opinions expressed are those of the author alone.

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tance of the problem and the extent of the necessary studies, is none too long.

A recital of only a few of the subjects which are being studied and which, in the judgment of the Committee, are necessary, will give some idea of the scope of the investigation. *Study 1* is a compilation of existing material, giving the extent of illness and of physical and mental defects prevailing in the United States. *Study 4* is a survey of statistical data on medical facilities in the United States. *Study 5* consists of surveys of medical services in several large cities, small cities, and rural communities. *Study 6* is on the cost of sickness, during a 12-month period, among various representative population groups, including the incidence of sickness. *Study 6-b* is on the cost of living in the United States, including detailed information regarding expenditures for medical service. There are studies on the cost of irregular types of medical practice; the service of pharmacy; the cost of dentistry; the cost of hospitalization; various studies on capital investment of physicians, dentists, and hospitals; pay clinics and group clinics; existing applications of the insurance principle to illness; hospital service for patients of moderate means, etc.

It will be recognized, therefore, that the Committee on the Cost of Medical Care is engaged in an extensive study of the economic aspects of the care of the sick and the prevention of illness. It is essentially a fact-finding committee. It is not committed to any theories nor has it even at the end of two years of study any solutions to offer. It hopes that at the completion of its studies it will have the facts with regard to several fundamental questions, namely, "the extent to which the burden of the cost of medical care and the incidence of sickness fall upon various economic and social classes in various types of communities; the proportion of the cost of medical care in typical communities borne by the patient, the community, and the physician himself; the financial returns to physicians, and the comparative adequacy and economy of medical care under diverse plans and diverse programs of emergency or distributed payment."

It is apparent that this problem is part of the much larger problem involved in the adjustment of individuals to rapidly changing economic and social conditions. It is comparable to the conditions that arose a few decades ago when new inventions and sanitation made a revolution in the style of living of the great mass of laboring people of this country. Before wages could be adjusted to meet the new demands there was widespread unrest among the working classes. It was the day of the cry for "a living wage," meaning, by that, a wage that would enable them to have those comforts in their home which were, only a short time before, the luxuries of the rich, but which had become the necessities of a changed style of living. This is part of the problem that hospitals are struggling to solve to-day: accommodations and general care are demanded of a far higher grade than was necessary a generation ago. Therefore, in seeking solutions for the present problem it should be borne in mind that since the year 1913, which is used as a normal for purposes of statistical studies, there has been an increase in the general cost of living of which the cost of the care of the sick is only a part. There is no evidence to support the view that hospital costs or physicians' charges have increased disproportionately to the cost of other commodities that enter into modern living. Along with the general improvement in living conditions has gone a tremendous advance in medical knowledge. The methods of diagnosis and treatment of disease have become more numerous and more complex and require expensive and complicated apparatus. Due to these and other causes, the cost of medical care has actually increased. Better accommodations are provided and more skilled workers are engaged in the care of the sick than was

formerly the case, for all of which someone must pay. The real problem is, *"Who* shall pay for it?"

When the facts are all at hand it seems quite likely that the Committee will be able to offer suggestions that will at least assist in solving some of the secondary problems that enter into the present cost of the care of the sick. Among these are the following:

(1) How can rural communities receive the benefit of modern advances in medicine?

(2) How can the present waste be eliminated, occasioned (*a*) within the medical profession by poorly qualified general practitioners and poorly trained specialists, and (*b*) among the laity by employment of quacks, self-medication, and insistence upon unnecessary types of treatment and hospital accommodations?

(3) How may all the various kinds of necessary medical service be most efficiently organized for the delivery of adequate medical care, so that individual, group, and institutional agencies may occupy their proper places?

(4) How far can governmental or industrial agencies enter into the problem without weakening or destroying individual initiative in the medical profession, or interfering harmfully with the individual contact of physician and patient?

(5) What improvements can be made in hospital construction and management which will lower the cost of hospitalization?

When the above more or less secondary questions are dealt with in some manner, there still remains the main problem. If all of the above problems were solved perfectly, the solution would operate to make slight reductions in the total cost of sickness, but it would not be of any appreciable benefit to those individuals of moderate means who face unusual and unprepared-for expenses because of illness. The question would still remain, "Who is to pay the expenses incurred for illness among people of moderate means?" The rich pay their own expenses and the community cares for the indigent. In a general way there are only two answers, either the sick must pay their own expenses or the expense must be distributed to other members of the community. Experience shows with fair conclusiveness that there are large numbers of instances in which, because of the type of sickness or injury or its long continuance, the patient of moderate means cannot himself meet a reasonable expense for adequate care. It seems necessary to devise some means of distributing the expense. The physician himself has attempted to distribute the expense among his own clientele by requiring the well-to-do to pay larger fees than do persons of moderate means. By so doing he has subjected himself to much criticism for having different prices for the same service. It is also an almost universal practice among physicians not only to do a large amount of pure charity work, but to reduce or cancel the charge in many cases in which the patient has a small income. The physician himself thus assumes part of the financial burden of caring for the sick in families of moderate incomes. These attempts of the physician to distribute the cost of medical care are unsatisfactory: (1) to the physician, who has to assume part of the bill himself; (2) to the well-to-do, who are paying part of the bill through larger fees to the physician, and (3) to the person of moderate means, who is often placed in the embarrassing position of asking partial charity of his doctor.

The Committee on the Cost of Medical Care hopes that its study will point out a more satisfactory method of distributing the cost of medical care of the people of moderate means, who, after all, constitute the bulk of our population. Among the various methods advanced, the Committee has as yet no opinion as to which is the best. It is well aware that the medical profession is almost unanimously opposed to any system

of state medicine on the grounds that it weakens individual initiative among physicians and interferes with those close individual relationships which have always existed between patient and doctor. It seems obvious, however—and is already working out in practice—that the great field of preventive medicine should be largely a function of the government—municipal, state, and national—and that the cost should be distributed among all the people by taxation.

A part of the Committee's investigation concerns itself with those large industrial corporations that are furnishing complete medical care to their employees. It will have an extensive study to offer along this line in the near future.

The Committee is also studying the attempts now being made to apply the insurance principle to cover the costs of medical care. There have always been great difficulties in the application of this type of insurance, but it is not likely that they are insurmountable. If some form of health insurance could be worked out for people of moderate means that would pay at least a large percentage of the expense incurred by sickness and that would permit the patient to choose his own hospital and his own doctor, such a system could be put into practice with the minimum of opposition.

It seems probable then that the final recommendations of the Committee will be concerned only partly with an attempt to reduce the cost of medical care. If its investigations shall lead to more thorough cooperation among all of the agencies that care for the sick and thus eliminate waste, if they point to better methods of prevention of disease and injury, if they assist in ridding the medical profession of poorly qualified practitioners and untrained specialists, if they lessen the number of persons who apply to uneducated cultists of various types, if they can bring about more economical construction and management of hospitals, and if they can indicate the limits to which governmental and corporation control of the practice of medicine may be put into force without interfering with medical progress, in so far will their recommendations be of use in lessening the cost of medical care.

As individuals, however, we are not so much concerned with a general reduction of the cost of sickness that affects us only indirectly. We are particularly and vitally concerned with our own individual problems, when we are faced with large and quite unforeseen expense brought about by sickness. The real problem in the end will be to show the great mass of people of moderate incomes some method or methods by which they may pay for what they are already receiving. It is futile to publish magazine articles berating the medical profession for the sins of a few charlatans or profiteers among them, or, on the other hand, to blame the public because it pays more for the super-luxuries of the day than it does for medical care, and for not saving money for sickness which it can not possibly foresee. The problem is an economic one. It can be solved satisfactorily only after all the facts are at hand and have been analyzed so as to give them their proper relative values. The Committee looks upon this as its task and hopes that at the conclusion of its investigations it will have sufficient data to enable it to present constructive recommendations.

DISCUSSION

DR. HARVEY AGNEW (Toronto, Canada): I have enjoyed exceedingly hearing this paper, and I must congratulate the author upon the lucid manner in which he has outlined the problems that are now facing this Committee on the Cost of Medical Care. We have been following the various announcements of the Committee and members of the Committee with great interest, because we realize that many of the problems which you are

facing in the United States are problems very similar to those which we have to face here in Canada and feel should be studied thoroughly by our organization, the Canadian Medical Association. We have the same difficulty that you have, namely, a number of journals publish articles berating the medical profession, berating the hospitals, and giving the impression that everyone who looks after the sick is more or less obtaining all that the traffic will stand. It is particularly unfortunate that the public, through magazines and occasional newspaper articles, should be given this impression, because it is decidedly unfair to many of our hard-working, unselfish doctors, and our devoted hospital workers, who are spending so much of their time in helping the public, very often without thanks for services gratuitously given.

Here in Canada we have been studying this question and undertaking various experiments along the lines suggested for study by Dr. Christie; for instance, national health insurance has been made a point of study by the Canadian Medical Association and all the various affiliated provincial associations. In the Province of British Columbia, on the Pacific Coast, they have made a most intensive study, and the Government of the Province has now a commission which is going into this question thoroughly. We have, on the prairie, a large number of municipal hospitals organized and financed by the people in the rural communities and giving these subscribers reduced rates. A "ticket," or subscriber system, prevails in certain areas in the Maritime Provinces and in Saskatchewan. We now have a maternity allowance of twenty-five dollars which helps the mother at that particular time. In Ontario we have a Royal Commission on Public Welfare which is studying hospital costs, hospital organization, hospital management and all of the many details which go to contribute to the hospital factor in the cost of medical care. We have a joint committee of the Canadian Nursing Association and the Canadian Medical Association studying the nursing question to see if something can be done to make this great branch of the healing profession of still greater service to the public and at less cost to them, at the same time safeguarding the income of our nurses.

On January first, the Canadian Medical Association will start a new scheme of periodic health examinations. In this we are aided by the insurance companies, who are permitting the general practitioners of Canada through the Medical Association to examine what ultimately may be practically all of the policy holders in the various insurance companies. This will be a periodic check-up done by the doctors themselves, the patient being referred back to *his own family physician* for this examination. We feel that this will be a great step forward in prevention of disease and therefore a means of lowering the cost of illness to the nation. I was pleased to hear Dr. Christie outline some of the main considerations that must be borne in mind if some form of health insurance is to be introduced. Here our own opinions are rather divided upon that question. As yet there is no unanimity, but we have made as intensive a study of this as possible, and this study is still going on. We feel that it is not wise to stampede the public and our legislators into such a drastic change in our system of caring for the public. There are many points to be considered; we would hope that, if such a scheme were introduced, it would work for the benefit of all, but we do not want to go "from the frying pan into the fire." Therefore the motto of organized medicine has been that of watchful preparedness. We are prepared to offer the advice when and if it be requested, but we do not feel like urging a nebulous measure with its ill-defined powers for good or for evil. I think that the majority of our students of this question feel that if, at any time, we have

some form of national health insurance, it should embody certain very definite stipulations. For instance, we feel that it is highly essential that the patient have the right to choose his or her own physician. We also feel that it is very essential that the doctor be paid for services rendered and not upon a *per capita* basis, such as is frequently done in lodge practice. We wish to avoid some of the pitfalls that have bothered the medical profession in England during the last decade. We feel that any form of health insurance of this type should include the whole family, not only the breadwinner. We also feel that the insurance should cover not only the cost of medical attention, but should cover the hospital cost, nursing cost, and all laboratory expenses, such as pathological examination, X-ray examinations and the like. Also, if any such form of insurance is to be introduced, it should be of a compulsory nature so that we do not have the ones who are likely to need it coming in and the ones who are in good health staying out; it should be compulsory for all people who are below a certain salary or income. We are all waiting, in this country, with a great deal of interest for the final report of the Committee on the Cost of Medical Care.

THE PRE-RADIUM TREATMENT OF CARCINOMA OF THE UTERINE CERVIX[1]

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MOST surgeons and gynecologists are now agreed that once a definite diagnosis of uterine cervical cancer has been made, the case is one for radiation treatment, with the possible exception of the infrequent Stage I growths, in which surgery or radium may be used with equal success.

EXAMINATION

The patient should first be carefully examined, not only to determine the extent of the local disease but to ascertain the general condition. It is especially necessary to ascertain if any metastatic malignancy is present, and if the patient is in condition to receive radium treatment. It is important that the gynecologic examination be done gently, as rough examinations have a tendency to disseminate the disease. Upon the results of the gynecologic examination, the patient should be classified as having a Group 1, 2, 3, 4, or 5 cervical cancer, in accordance with the classification of Schmitz. In making the gynecologic examination, it is important to determine if the uterine canal is patent, and if so, to ascertain and record its length (by means of a sound). A biopsy of the lesion should be taken at this time. Biopsy carries insignificant hazards in cervical cancer because the lymph and blood channels are already blocked by the ulceration that is invariably present.

CLASSIFICATION OF PATIENTS

Before considering the method of treatment in a particular patient, it is well that the growth present be classified, in order to provide a convenient means for discussing the therapy. A classification that has proven popular in this country is the one proposed by Henry Schmitz, which is quite simple, and based entirely on the local physical findings. The carcinomata are divided into primary and secondary or recurrent. The factors which determine the grading of the primary carcinomata are as given in the following grouping.

Group 1 comprises the earliest lesions, which, unfortunately, are the least frequently seen. The growth is the size of a navy bean, is clearly localized within the cervix, and the uterus has normal movability. (A uterus normally movable can be displaced downward without causing distress to the patient or the use of an unusual amount of force, until the cervix appears at the vaginal outlet when pulled by a tenaculum forceps attached to the cervix.) This group is sometimes called "operable."

Group 2 includes cases in which there is a wide or peripheral invasion of the cervix or body of the uterus, a doughy consistency of the paracervical tissues, and decreased mobility (evidenced by failure of the uterus to be completely displaced downward when pulled by a tenaculum forceps). This group is often called "doubtfully localized" or "borderline."

Group 3 includes cases in which there is infiltration of one or both parametria, with or without regional lymph node involvement or invasion of adjacent organs, but the structures are, as a mass, still movable, though elasticity of the tissues is lost. This

[1]Read before the Radiological Society of North America, at the Fifteenth Annual Meeting, at Toronto, Dec. 2–6, 1929.

group is sometimes called "advanced" or "inoperable," and is the condition most commonly present when the patient presents herself for radiation treatment.

Group 4 cases are characterized by absolute fixation of the tissue (the "frozen pelvis"), wide local extent of the disease, and usually distant metastases. This group is often called "terminal," "fixed," or "inoperable." The "complicated" carcinoma is one associated with general disease in a patient who is considered a poor surgical risk.

The characteristics of the groups in the recurrent carcinomata are: *Group R 1* contains the local but normally movable recurrence; *Group R 2*, the regional but movable recurrence; *Group R 3*, the cases with local and regional movable recurrences, and *Group R 4*, the recurrence, with fixation of the mass.

Since the use of radium in uterine cancer is a hospital procedure and the patient is not acutely ill, there frequently occurs some delay until consent has been secured to proceed with the treatment. Many women will delay some weeks "getting ready" to go to the hospital. What treatment should the patient receive in the interval? Should the physician administer no treatment in uterine cervical malignancy until radium is actually applied?

It is a fact that the majority of patients suffering from cervical cancer, when first seen by the physician, already present an advanced stage of the disease. Schmitz, in his analysis of 332 primary cases, found that 49 per cent had Stage III growths when treatment was first begun and 30 per cent had Stage IV growths—a total of 79 per cent advanced lesions. Other writers report statistics in about the same proportion.

CONTRA-INDICATIONS FOR RADIUM

Recently Strachan has enumerated seven contra-indications to the application of radium that are well to keep in mind. These have been emphasized in an editorial in the *Journal of the American Medical Association:*

"General emaciation and cachexia is a condition that is unfavorable to radium treatment; in such cases the method is liable to result in rapid deterioration and early death. When the red cell count is below 3,000,000 or the hemoglobin index below 40, radium should not be applied; radium treatment has a tendency to produce a degree of anemia, probably by a systemic action on the spleen, and this in the presence of a pre-existing severe anemia may be dangerous. If hydronephrosis or pyonephrosis should be detected by the presence in either loin of a tender swelling, radium should not be applied; the resulting increased fibrosis in the broad ligaments will add to the obstruction. Rectovaginal and vesicovaginal fistulas are contra-indications, as radium in such cases is apt to cause intense local irritation with sloughing. Radium should not be used in the presence of any inflammatory pelvic lesion; a foul sloughing condition of the growth is one of the most common and important of these; if radium is used before the inflammatory condition has been cleared up the probable consequence is a massive necrosis with some toxemia and pelvic parametritis or peritonitis. In cases in which the whole pelvis is extensively infiltrated with extension from the cervical growth the use of radium even supplemented with high voltage roentgen therapy seems often to hasten rather than to delay the end. Finally, radium should be withheld in the presence of impaired metabolism, especially defective excretion of nitrogenous waste products. Dr. Strachan is careful to point out that some of these conditions may be overcome, and radium may then be used. One temporary contra-indication which he does not mention, the condition of pregnancy, has been emphasized of late by other writers. The risk of radium to the fetus is almost, but not quite, as great as the Wertheim operation. Even so, it may at times be necessary to sacrifice the child's interest in order to treat the mother while there is still a fair prospect of saving her life."

EXTERNAL RADIATION

When radium is applied in the uterus or vagina, its ability to successfully destroy cancer cells probably does not reach beyond 2 or 3 cm. from the walls of the applicators. It is apparent, therefore, in Stage III or IV cervical growths, that intra-utero-vaginal radium alone cannot be expected to control the condition and that additional radiation from without is also necessary. This can be applied in the form of high voltage (200,000 volts) X-ray treatment, or by means of the so-called "radium pack," by which the entire pelvis is cross-fired through a number of different portals. In such advanced cases, the question is, Should this external radiation precede the internal radium treatment or not? There appears no question but that the extra-uterine involvement is the greatest source of danger to the patient and may result in perforation into the rectum or bladder, or permit the growth to spread beyond the pelvis. It is also true that the outer limits of a tumor are usually the most active in growth. In view of the above, would it not appear more logical to administer the external radiation first?

The views of Prof. Claude Regaud, associate of Mme. Curie, of the University of Paris, who has had perhaps as wide an experience as anyone with the radiation treatment of cancer, are interesting in this connection.

Regaud believes that any attempt to reach the parametrial involvement in cervical cancer by radium needles, implants, seeds, etc., is not good practice. He contends that the interstitial use of radium in this region is dangerous. The simultaneous employment of radium puncture and intra-utero-vaginal irradiation may cause secondary rays excited by the impingement of gamma rays on the platinum needles or seeds. Such beta therapy increases the danger of radium necrosis. Regaud states that the association of X-rays or radium at a distance, with radium applied utero-vaginally, is the correct method when the parametrium is invaded. He contends that if X-rays are used to give the external treatment, they should always precede the radium treatment, while if external radium therapy at a distance is used (radium pack), it should follow the internal radium therapy.

Pack, in describing Regaud's method, states:

"The association of radium therapy and roentgen therapy is for the purpose of securing the combined action of the X-rays (in the peripheral part of the neoplastic territory) and of radium in the uterus and vagina. When the neoplasm has extended beyond the uterus (parametrium, vagina, pelvic adenopathies) this combination is the method of choice and is the rule in the majority of instances. Regaud believes that the order of succession of these two agents is not an indifferent matter. The inefficiency of the X-rays in the treatment of recurrences following previous radium therapy has been shown by Regaud (1923) *à propos* of epitheliomas of the skin and mucous membranes in general. X-rays are especially inefficient after radium therapy has been given by the utero-vaginal method. To use these agents in the correct combination, roentgen therapy should be administered first, followed immediately, or after a very short period of rest, by radium therapy."

CERVICAL INFECTION

A factor to which many American radiologists have not given proper consideration in treating malignancy is the local infection that accompanies so many of these growths. The rôle of infections in the dangers and complications incident to the use of radium is particularly important in cancer of the uterine cervix. Local infection invariably accompanies cervical cancer at the moment it opens into the vagina. The infection usually progresses with the progress of the cancer and probably does as much, if not more, to break down the resistance of the patient as does the growth itself. The infection is

at first superficial, but later extends deeply, and the infiltrations that one palpates may be due to infection, newgrowth, or both. If an attempt is not made to first control this, radium may transform the local infection into an acute pelvic cellulitis, a suppurative salpingitis, a circumscribed phlegmon of the pelvic tissue, a generalized peritonitis, or a septicemia.

The rapidity with which some physicians apply radium, immediately upon diagnosis of a cervical cancer and without any preliminary treatment, is to be condemned. A better procedure is to give copious, mild, antiseptic vaginal douches several times each day until the local infection is controlled. Pack, in describing Regaud's preliminary radium treatment, states:

"The putrefactive microbes disappear readily under this local treatment, but the pyogens, namely, the staphylococci and streptococci, are more difficult to destroy. Autogenous vaccines are responded to by the staphylococci, but the streptococci, particularly those of the dangerous hemolytic type, are very resistant. In every instance where internal radium therapy has been followed by severe pelvic infection, the preceding bacteriologic analysis has demonstrated the presence of hemolytic streptococci: on the contrary not every patient harboring these streptococci within her vagina will suffer this complication.

"The ablation or curettage of cancerous vegetations of the uterine cervix has certain advantages: it facilitates treatment; it may suppress the suppuration from the infected cervix; it frees the implantation of the cervical tumor from the orifice of the uterine canal; it permits closer approximation of the radium foci to the outlying cancer tissue; it favors cicatrization and lessens the danger of toxemia from absorption. A bleeding, infected, sphacelic, 'cauliflower' cervical tumor should be amputated, preferably by diathermo-coagulation, previous to the introduction of the radium into the vagina and uterine canal."

Kaplan, in describing the method used at Bellevue Hospital for these patients, states:

"Treatments are planned according to the extent of the lesion present. If marked ulceration and infection are present in the vagina, a course of disinfection with douches initiates the treatment. The patient is shaved and cleansed externally; the bowels are cleansed with enemas. Douching with boric acid solution or with 2 per cent glucose solution twice daily is carried out until the vagina has been cleansed thoroughly and much of the induration about the cervix reduced. Following the douching, the vagina is irrigated with 2 per cent methylene blue solution, a mild antiseptic which seems to clean up the infection more rapidly.

"Radiation is not begun until the disinfection or cleansing is completed, so that little infection is present in the vagina when the treatment is given. Meanwhile the general condition of the patient is improved by dietetic and hygienic methods. Constipation, which is present in nearly all cases, is treated by mineral oil and magnesia, and enemas if necessary."

Pinch, in describing the technic used at the internationally known Radium Institute of London, states:

"Patients suffering from carcinoma of the uterus often present themselves in a condition which negatives any attempt at immediate treatment. The cervix, fornices, and vaginal walls are extremely ulcerated, covered with washleather sloughs, and exude a constant, copious, purulent, offensive discharge. It is of the utmost importance to render the diseased surfaces as clean as possible before using radium. Douches of Tr. Iodi. drams 1 to 1 pint of warm water should be used two or three times a day, a Ferguson speculum should be passed, and any loosely adherent sloughs detached with forceps or a probe covered with cotton wool. This treatment should be persisted with until all detritus and sloughs have been removed and the discharge is no longer offensive. If the iodine douche proves unduly irritating, glyco-thymoline (1-20) may be substituted for it in the later stages. A douche of Flavine, 1 in 2,500, should be given on the day before, and early in the morning of the day on which the radium is inserted."

During this preliminary treatment the patient, if able, may be up and around. She should be thoroughly examined to determine the extent of the lesion and to ascertain if any distant metastasis is present. X-ray examinations of the chest, spine, and pelvis are valuable in ruling out metastasis in these parts—favorable areas for the growths to appear. In addition, every effort should be made to eliminate sources of focal infection and to improve the general health of the patient.

After a week or ten days of preliminary treatment, the cervical canal should be gently dilated by the use of graduated uterine sounds, and the length of the uterine canal noted. The patient is then returned to bed and her temperature taken at frequent intervals during a period of twenty-four hours. If there is no increase in temperature, the patient is ready for the internal radium treatment.[2]

PRELIMINARY RADIUM OR ELECTROTHERMIC AMPUTATION

When the cervical canal is filled with a cauliflower growth, or an ulcerating growth at the external os, and localization of the cervical canal is impossible, the patient should not be given the principal internal radium treatment. Such cases should receive preliminary radium treatment by the embedment of radium needles or implants, or the cervix should be removed by electrothermic measures.

Kaplan, Pfahler and others advocate the amputation of the cervix or the removal of malignant masses by electrothermic means immediately preceding the insertion of radium in certain cases (a small percentage) of cervical cancer—as when the cervical canal is obstructed by a large cauliflower growth blocking the vagina or there is much hypertrophy of the cervix associated with a large amount of fibrous tissue which may help to shield carcinoma cells. When such treatment is carried out, preliminary radium treatment is not necessary, as the uterine canal is rendered patent and the principal radium treatment can be readily carried out Sometimes complete removal is not possible. In such instances, as much growth as feasible is removed and then radium needles are inserted in the remaining mass. When the mass has receded the uterine canal may be located and the principal radium treatment carried out.

If preliminary radium is used, the uterine canal will usually become sufficiently patent in 10 to 20 days, to permit the introduction of an intra-uterine radium applicator. In fact, these cases usually respond remarkably to such preliminary radium treatment. There is a danger that the patient or physician may think that further radium is not necessary because the excrescences are cleared up so readily.

Preliminary radium treatment or electrothermic amputation is absolutely necessary in all cases where the growth has proliferated to such an extent as to occlude the cervical canal, if the maximum results are to be secured. The principal radium treatment should not be given until the uterine canal is rendered patent. Many radiologists are now of the opinion that the best results in cervical cancer can only be secured by treating the entire uterine canal with heavily filtered radium. This necessitates the predetermining of the length of the uterine canal, in order that the proper type of applicator may be provided. If the cervix is to be first amputated, the length of the uterine canal will be shortened and the radium therapist must consider this factor

[2]Since this paper was read before the Radiological Society, the 1929 report on "Radium Treatment of Cancer of the Uterus," of the Cancer Research Committee of the Marie Curie Clinic (London Association of the Medical Women's Federation) has been published. This report covers 300 patients treated during the previous three and one-half years. The following is quoted from the technic of preliminary preparation as used at the Marie Curie Clinic:

"The preparation of the patient includes a general examination, a blood count, and urine analysis; when necessary a cystoscopic examination is made to determine the condition of the bladder. A bacteriological examination is important. Disinfection is carried out with acriflavine douches (1 in 1,000 normal saline) twice daily for a day or two before treatment. In advanced cases with extensive necrosis and foul discharge, rest in bed for a few days and a more thorough cleaning-up is advisable. In cases of severe anemia the patient is kept in bed for two or three weeks for special treatment before the radium is applied."

when constructing the intra-uterine applicator.

SUMMARY

In conclusion, the following in regard to the pre-radium treatment of cervical cancer should be emphasized:

1. Every case of advanced cervical cancer should receive external radiation and if this is given by high voltage X-rays, it should preferably precede the internal radium treatment.

2. Local infection constantly accompanies cervical cancer and no case should receive internal radium treatment until the infection has been controlled by suitable douches, etc.

3. The principal internal radium treatment should not be given until the uterine canal is patent, as the best results are secured by placing radium the entire length of the canal. If the canal is occluded it should be treated by preliminary radium until rendered patent, or the cervix should be amputated by electrothermic measures preceding the principal internal radium treatment.

4. Every effort should be made to eliminate sources of focal infection and to improve the general health of the patient.

BIBLIOGRAPHY

(1) Editorial: Treatment in Carcinoma of the Cervix. Jour. Am. Med. Assn., Sept. 21, 1929, XCIII, 923.

(2) KAPLAN, IRA I.: Radiation Treatment of Malignancy of the Cervix by Radium Emanation. RADIOLOGY, October, 1927, IX, 314.

(3) PACK, G. T.: The Management of Uterine Malignancies at the Radium Institute of the University of Paris. South. Med. Jour., July, 1928, XXI, 505.

(4) PINCH, A. E. HAYWARD: A Manual of Technic in Radium Therapy (Radium Institute, London), 1926.

(5) QUIGLEY, DANIEL THOMAS: The Conquest of Cancer by Radium and Other Methods. F. A. Davis Co., Philadelphia, 1929.

(6) SCHMITZ, HENRY, and HUEPER, WILLIAM: The Prognostic Value of the Histological Malignancy Index and the Clinical Grouping of Carcinomata of the Uterine Cervix. RADIOLOGY, November, 1928, XI, 361.

(7) STRACHAN, G. I.: Contra-indications to Irradiation in Carcinoma of the Cervix. Proc. Roy. Soc. Med. (Sect. Obst. and Gynec.), July, 1929, XXII, 50.

(8) SWANBERG, HAROLD: Regaud Technic of Radium Application (with Modifications) in Uterine Cervical Malignancy. Radiol. Rev. and Chicago Med. Rec., September, 1929, LI, 375.

(9) SWANBERG, HAROLD: Malignancy of the Uterine Cervix and Its Treatment with Heavily Filtered, Multiple Centers of Radium: Use of New Applicator. Radiol. Rev. and Chicago Med. Rec., March, 1929, LI, 107.

THE CAUSE OF DEATH FROM RADIUM[1]

By A. JAMES LARKIN, M.D., CHICAGO, ILLINOIS

WHAT might be said to be the cause of death should a patient die from what would appear to be general rather than the local effects of radium rays prompted the work discussed in this paper. The local changes brought about in tissues irradiated for clinical purposes are fairly well described and morphologically understood.

To ascertain, then, the cause of death, the following method was devised: the whole body of young rabbits was exposed to the gamma rays from radium. It was necessary first to determine the lethal dose. This having been accomplished, the study turned to the clinical changes resulting from lethal and sublethal doses and finally to the pathological changes resulting from each.

The technic consisted of placing young rabbits in a round cage twelve and one-half inches in diameter, the radium being suspended in the middle of the cage two inches from the floor. In a second series the animals were placed in a cage seventeen inches square. In the one series the distance from the radium to the farthermost part of the animal was six and one-fourth inches, in the other series this distance was eight and one-half inches. The amount of radium varied between 15 and 200 milligrams, the amount used seeming to be immaterial so long as the milligram-hours were the same. It seemed also to be immaterial whether the dosage was delivered at one sitting or more,

TABLE I

ANIMALS RECEIVING LETHAL DOSE OF RADIUM

CLINICAL OBSERVATIONS

Number	eleven young and one adult
Average age at beginning	29.2 days
Average beginning weight	480 grams
Average weight at death	441 grams
What would have been average normal weight at time of death, considering normal life expectancy	730 grams
Average percentage of loss of weight	8.1 per cent
Average percentage normal gain should have been	52 per cent
Average dose of radium given	7,474 milligram-hours
Average duration of life	17 days
Shortest duration of life	11 days
Average dosage per kilo	15,570 milligram-hours
Average dosage round cage	7,663 milligram-hours
Average dosage square cage	7,200 milligram-hours
Round-cage animals received dosage equal to (at one inch distance)	213 milligram-hours
Square-cage animals received dosage equal to	113 milligram-hours
Average weight for 213 mg.-hr. to dispatch	555 grams
Average weight for 113 mg.-hr. to dispatch	296 grams
Average age for 213 mg.-hr. to dispatch	39 days
Average age for 113 mg.-hr. to dispatch	19 days
Smallest single dose to dispatch	4,800 milligram-hours
Largest single dose to dispatch	8,600 milligram-hours
Single dose to dispatch in fourteen days	7,200 milligram-hours
Divided dose, six days apart, to dispatch in fourteen days	7,900 milligram-hours
11,217 mg.-hr. in three doses during eight days, required to dispatch	44 days
Adult rabbit given 9,000 mg.-hr. survived.	
Same rabbit given 11,590 mg.-hr. lived from initial dose	165 days
Same rabbit given 11,590 mg.-hr. lived from second dose	105 days

[1]Read before the Radiological Society of North America at the Fifteenth Annual Meeting, at Toronto, Dec. 2–6, 1929.

TABLE II

ANIMALS RECEIVING SUB-LETHAL DOSE OF RADIUM

CLINICAL OBSERVATIONS

Number of animals	eleven
Average age at beginning	24 days
Average beginning weight	290 grams
Average weight at death	537 grams
What would have been average normal weight at time of death, considering normal life expectancy	790 grams
Average percentage of gain in weight	85 per cent
Average percentage normal gain should have been	172 per cent
Average dose of radium given	5,100 milligram-hours
Average duration of observation	36 days
Average dosage per kilo	17,544 milligram-hours
Average dosage per round cage	none
Average dosage per square cage	5,100 milligram-hours
Round-cage animals received dosage equal to (at one inch distance)	none
Square-cage animals received dosage equal to (at one inch distance)	80 milligram-hours
Average weight for 80 mg.-hr	290 grams
Average age for 80 mg.-hr	24 days

TABLE III

ANIMALS RECEIVING LETHAL DOSE OF RADIUM

WHITE BLOOD COUNTS

12-18-27	12-21-27	12-22-27	12-24-27	12-26-27	12-27-27	12-28-27
No. 30 10,000	3,000	1,500	1,500	500	Dead	
No. 31 8,000	4,000	2,500	1,500	4,000	1,000	Dead
No. 32 9,000	4,000	1,500	1,000	1,000	2,000	1,000
No. 33 10,000	5,000	2,500	500	500	Dead	
No. 34 11,000	6,000	3,000	3,500	1,500	1,000	Dead
C. U.						
No. 16 14,000	4,000		900	500	Dead	

so long as the total amount was delivered within one week. If a month intervened between doses, a considerably higher number of milligram-hours was required to cause death. The reason for this phenomenon is not clear.

Observations upon the general appearance of the animals yielded rather meager information. Little change was noted except a reduction in activity to varying degrees, and anorexia. Occasionally diarrhea was observed. Death apparently came suddenly after a period of extreme quiet. Loss of weight was regularly present or there was a gain in weight far below that of the normal for the given rabbit. The white blood count was regularly reduced and to an extreme degree in the animals that died: but little change was noted in the red blood count or hemoglobin. Death apparently was always uneventful. Unfortunately, none of the animals was observed as it died—one was still warm when found. It is regrettable that the value of the autopsy in several of the animals was reduced, due to the post-mortem changes.

DISCUSSION

In every instance death was accompanied by certain phenomena.

Loss of weight, either actual or relative, was present in animals given the lethal dose of radium. The average loss of weight amounted to 8 per cent, whereas the normal gain in weight, during the period of observation, should have been 52 per cent. In animals given a sub-lethal dose, there was a gain of 85 per cent during the period of observation, whereas it normally should have

TABLE IV

AVERAGE WHITE BLOOD COUNT—FIVE RABBITS

12-18-27	12-21-27	12-22-27	12-24-27	12-26-27	12-27-27	12-28-27
9,600	4,400	2,200	1,600	1,400	1,300	1,000

TABLE V

ANIMALS RECEIVING LETHAL DOSE OF RADIUM

BLOOD COUNT SUMMARY

Number of animals	6
Average white blood count before radium	10,300
Average lowest white blood count after radium	750
Average time white blood count after radium	8.5 days
Average red blood count before radium	7,500,000
Average lowest red blood count after radium	5,800,000
Average time red blood count after radium	12 days

TABLE VI

ANIMALS RECEIVING SUB-LETHAL DOSE

BLOOD COUNT SUMMARY

Number of animals	9
Average white blood count before radium	5,500
Average lowest white blood count after radium	3,820
Average time of lowest white blood count	15.6 days
Lowest white blood count with which animal survived	2,200
Average red blood count before radium	4,900,000
Average lowest red blood count after radium	4,600,000
Average time of lowest red blood count	12 days
Average white blood count 48 hours after radium	10,100

been 172 per cent. The loss of weight, either actual or relative, was less in the animals given the sub-lethal dose, in each instance and in the average.

The *white blood count* was reduced in all animals observed, but to a greater extent in the case of the lethal dose than in the sub-lethal doses. Temporary leukocytosis occurred in all observed instances. Unfortunately blood counts were not made in many instances: the lowest white blood count recorded was 500 (death ensued within twenty-four hours); the lowest count observed in which the animal survived was 2,200.

All animals receiving an appreciable dose became *apathetic* in proportion to the dosage. Animals receiving the lethal dose practically all remained perfectly quiet for from twenty-four to thirty-six hours before death.

Anorexia seemed also to be a reliable indicator of reaction on the part of the animal. Failure to eat for a couple of days presaged death in most instances.

In some animals the shedding of fur was unquestionably greater than normal. Patchy *epilation*, however, did not occur.

There was marked *diarrhea* in one instance.

Thus, the four clinical findings, *loss of weight*, *leukopenia*, *apathy*, and *anorexia*, were constantly present and in direct proportion to the dosage.

Certain factors were of marked significance in determining whether the dosage would be lethal or sub-lethal, foremost among which was the age of the animal—the younger the animal the smaller the lethal dosage. The lethal dose was approximately twice as much in animals averaging thirty-nine days of age as it was in animals averaging nineteen days. In spite of the fact that the dosage per kilo was greater in sub-lethal doses than in lethal doses, the age of the animal seemed to be of the greater sig-

TABLE VII

COMMON MICROSCOPIC CHANGES

	Lethal	Sub-lethal
Bone Marrow	White blood count decreased Embryonic red blood count markedly increased. Dilatation, blood channels.	White blood count moderately decreased. Embryonic red blood count increased.
Kidney	Cloudy swelling of the convoluted tubules.	Moderately cloudy swelling.
Spleen	Lymphocytes few. Endothelial and reticular cells markedly increased.	Vascular distention. Endothelial hyperplasia.
Liver	Granular cytolysis. Cell membrane indefinite.	Granular degeneration of cytoplasm.
Heart	No common marked changes.	Normal.
Adrenal glands	No common marked changes. Normal to marked granular degeneration.	No common changes. Normal to slight reduction in stain.
Lung	Moderate hyperemia.	Normal.
Thyroid	No common marked changes.	Normal.
Thymus	Distention of vessels. Fifty per cent of parenchyma composed of lymphocytes and endothelial cells of blood vessels and lymphatics.	
Intestines		Fine granular degeneration of the lining epithelial cells.
Pancreas		No changes
Testicles	Granular degeneration of seminiferous tubules. No mitosis or spermatozoa.	

nificance. Of course, the weight was greater in the older animals. Lethal dosage, then, seemed to be in direct proportion to age. Any definite relationship between dosage and body weight *per se* could not be established.

A second factor associated with the lethal or sub-lethal character of the dose was the *time required for the lethal dose to act.* The shortest period between exposure and death was eleven days. The average elapsed time between treatment and death was seventeen days. These results seem to correspond to the period of maximum destruction of tissues as observed in daily clinical work, *viz.*, fourteen to eighteen days. When animals lived twenty days they usually survived. There were two exceptions: one had received multiple doses and the other was fifty-seven days old when exposed to radium. These two young animals and a single adult rabbit averaged eighty-three days' survival. Death in these instances was probably due to the secondary effects of the radium, *viz.*, serious changes brought about in vital structures or organs. At any rate, this is a problem for further study.

A third factor seriously affecting the character of the dosage delivered was the *duration of the exposure.* Briefly, dosage delivered within six days acts approximately the same as a similar dose delivered within two or three days. When the duration of the exposure is extended beyond seven days, in divided doses, the animal survives. In short, the longer the duration of the exposure beyond seven days the greater the dose tolerated. The increasing age of the ani-

mal may be a factor of greater importance than any possible acquired resistance. The problem of the latent period came to light in this investigation, but only as corroborative evidence. Inference might be drawn from the data gathered as to the latent period: that dosage delivered within seven days gives the same results as if delivered in a much shorter period, while dosage delivered over a longer period has to be increased to be lethal. Clinical experience seems to place the latent period at about six days. Here again is a problem for further study.

DISCUSSION OF MICROSCOPIC CHANGES

Of greatest significance are those changes found in the *bone marrow* and *spleen.* From the examination of these, it is seen that the white blood cells are markedly decreased. This finding is borne out by the white blood counts made upon a few of the animals. But little change was noted in the red blood cells so far as the count was concerned, but in the bone marrow embryonic red blood cells were increased. From this finding one may infer that the red blood content was not greatly affected but that there seemed to be some increased drain upon the red blood-forming organs. In an acute reaction it is unlikely that sufficient time elapsed to greatly influence the red blood mechanism. In the spleen it was noted that there was marked proliferation of the endothelial cells. Distention of the blood vessels and channels within these two blood-forming organs indicates profound changes in the circulation or in the circulating mechanism.

In the *kidney* and *liver* were found definite significant changes. There was cloudy swelling of the convoluted tubules, apparently in proportion to the dosage. In the liver granular cytolysis and destruction of cell membrane were evident also in proportion to dosage. The changes in these two organs would seem to indicate that there was some toxic substance eliminated through these organs.

The next change of importance was the destruction of almost the entire parenchyma of the *thymus gland,* leaving practically only endothelial cells and lymphocytes.

The *testicles* exhibited marked degeneration of the seminiferous tubules; there were no mitoses and no spermatozoa.

The heart, lungs, thyroid, adrenal glands, intestines, and pancreas showed no characteristic changes.

The *cause of death,* unfortunately, cannot be definitely stated. It is intimately and proportionately related to the white blood count, to the changes in blood-forming organs, namely, the bone marrow and spleen, and also closely related to the cells of the convoluted tubules of the kidney and the parenchymal cells of the liver, the latter two being excretory in function.

One other finding of great significance was the loss of weight. This finding varied directly in proportion to the dosage and was a reliable indicator of prognosis. The loss of weight might be attributed to the profound changes in the thymus gland or it may have been related to the changes in the blood-forming organs on the one hand or to the changes in the excretory organs on the other. (Unfortunately and inexplainably, there are no microscopic sections of the thymus gland in rabbits receiving sub-lethal doses. These organs were always removed at autopsy, but when the sections came through, the thymus was always absent.)

DISCUSSION OF THE GENERAL RESULTS

While the primary object of the experiments was not conclusively attained, yet some very significant information was brought to light. While the cause of death cannot be positively stated, yet it is so closely associated with the destruction of the white blood cells and with the loss of

weight that these two phenomena can be used as reliable indicators of impending death or probable recovery. The changes in the kidneys and liver may possibly be of great significance also, but it would seem more likely that these changes are secondary to the alterations in the white blood count, a viewpoint which is substantiated by clinical experience. White blood cells are extremely susceptible to radium rays, as evidenced by the leukopenia following heavy irradiation and by the rapid extensive destruction of the white blood cells in myelogenous leukemia. One contra-indication to heavy radium treatment clinically is a white blood count below 5,000. Counts below 3,500 are extremely dangerous. Further evidence that the changes in the kidneys and liver are not of the greatest significance is found in the fact that the microscopic changes in these organs were quite as marked in those animals receiving the sublethal dose and yet the animals survived, whereas in all those animals receiving the lethal dose, the white blood count went below 2,000. The only other factor which was a reliable indicator of prognosis was the loss of weight. If this factor could be definitely traced to the reduction of white blood cells or to the toxemia which so seriously affected the kidneys and liver or to the influence of the annihilated thymus gland, then one might conclude that the one or the other of these changes was the more important.

SUMMARY

1. Death due to external radium radiation is associated with *loss of body weight, extreme leukopenia, anorexia,* and *apathy.*

2. Death due to external radium radiation is associated with *marked degenerative changes in the bone marrow and spleen, cloudy swelling in the convoluted tubules of the kidney, granular cytolysis in the liver,* and *annihilation of the parenchyma of the thymus gland.*

3. *Lethal dosage* varied markedly with the *age of the animal,* the younger the animal the lower the dosage required. *Death occurred* within eighteen days, averaging seventeen days after exposure; and *dosage delivered within seven days acted as a unit* —dosage delivered in eight or more days required an increase to be lethal.

The experimental work discussed in this paper was begun in the laboratory of Professor Arthur L. Tatum, of the Department of Pharmacology, at the University of Chicago. Much credit is due him for the initiation of the methods employed and for valuable assistance during a considerable period of time and for suggestions upon its completion. The work was continued in the laboratory of Professor Lester R. Dragstedt, then Professor of Pharmacology at Northwestern University Medical School. For a short time, work was carried on in the Department of Physiology under the direction of Professor A. C. Ivy, of Northwestern University Medical School. The final work was done in the Department of Surgical Research at Northwestern University Medical School, under the direction of Professor Loyal Davis of the same college. The pathological findings were reviewed by Dr. H. R. Fishback, of the Department of Pathology. Acknowledgment with thanks is hereby given for the valuable assistance and many courtesies of these men.

DISCUSSION

DR. FRANCIS CARTER WOOD (New York): These interesting experiments on animals confirm in many ways the observations of the numerous earlier workers on the subject. The fall of the leukocytes was observed years ago after the first use of X-ray and radium. It is unfortunate that it is impossible to prove that the kidney and adrenal lesions observed are definitely due to a poison in the circulation. The early workers talked of a leukotoxine which was produced by the radiation, but that view has been abandoned and the clinical results obtained on cases of leukemia in human beings in which radiation has produced a rapid return to perfect health, makes it difficult to understand how a toxine could be produced by tissue destruction. In myelo-

genous leukemia a spleen weighing several kilos can be reduced to normal size in the course of a week or two, without the patient showing any evidence of a toxemia. The main value of these experiments is that general exposure of the body of either an animal or human being may cause prompt death. The loss of weight noticed in the rabbits is probably not important. Death occurred in human beings in the early days of radiation therapy more frequently from X-ray than from radium, for the radium, being approximately a point source, the intensity falls off rapidly owing to the conditions imposed by the inverse square law. X-ray, especially high voltage X-ray, is much more dangerous, and a number of patients have been killed by the exposure through a large portal with such radiation. The ordinary lead rubber is quite insufficient as a protection, and these unfortunate results have become much less frequent since the adoption of the large lead chambers to house the tube. No radiation then reaches the patient except through the portal. Nevertheless, even under these conditions, X-rays produced at 200 K.V. are scattered laterally throughout the patient's body to such an extent that it is possible by such scattered rays to see the bones of the hand in the fluoroscope at a distance of six or eight feet from the patient. That severe damage to the bone marrow may occur in susceptible subjects is obvious, and a number of deaths have occurred from radiation even under these conditions. The chief value of this paper, then, lies in rehearsing this important fundamental fact.

In experiments of my own on rats and mice, using X-ray, a marked variability in the animals as regards the time of death has been observed though they were all of the same strain, age, and weight. This suggests that there may be a great difference in the sensitivity of the bone marrow in different animals, a fact which we already knew from human pathology.

If the dosage is given slowly, a considerable number of animals die of pneumonia after the leukocytes have been reduced below a certain point. Others seem to die, as Dr. Larkin's rabbits did, from the anemia coupled with the organ-degenerations described.

DR. LARKIN (closing): I wish to thank the doctors for their comments. There were no instances of pneumonia in the animals treated with either lethal or sub-lethal dosage. This bit of work was done principally for personal reasons. The British early work did a great deal to clarify the actions of radium rays. There are many other works along this line, but this work was entered into for personal reasons. The facts are given to you just as they came. They seemed to be of practical significance in the treatment of patients day by day. The essayist is not a research man, but just makes his living by the practice of medicine.

EDITORIAL

NEW EXPERIMENTS ON CANCER CURE

It is an unfortunate thing that persons afflicted with cancer have had their hopes raised by over-enthusiastic newspaper reports of the San Francisco Coffey-Humber experiments, and are making great sacrifices, mortgaging their homes in some cases, to go there in the hope of being cured. Even the proponents of the experimentation do not claim any unusual treatment method or results to date. They are referring many of the early curable cases to management by radiation and surgery, refusing to use the Coffey-Humber injection on any but hopeless cases.

One reason why the physician should not grow enthusiastic over an alleged cancer cure is that he knows proof must be supplied of certainty that the patient had cancer, that it was made to disappear in all stages, and that it remained away permanently. A conclusive judgment regarding cure, therefore, before the passage of several years, would be illogical. In the presence of preliminary favorable results, the press and public do not understand this logic.

We understand that pharmaceutical firms are being bombarded with requests for the Coffey-Humber adrenal cortex extract. One firm is now making an adreno-cortin hormone for sale without claims. In the light of the fact that there are no publications on the preliminary experimental work of these men, such requests are highly premature. Neither are there any explanations of the character, dosage, or standardization of their extract. In a public statement to the Medical Society in Los Angeles on Feb. 17, 1930, Dr. Humber said that their extract was made by a "special process" from a part of the suprarenal cortex of sheep. He also said, "We have done no animal experiments —a thing we should have done, I admit."

On March 13, 1930, the Senate Sub-committee of the Committee on Commerce met in Washington, under a resolution directing Federal Government aid in discovering, investigating, and financing any successful or possibly practical cures for cancer. Many experts were called in to aid this Committee, and Dr. Coffey and Dr. Humber, of California, were also present. Dr. Coffey began by making a statement (in ten paragraphs) of his idea of governmental assistance in medical research, ending with: "Tenth, During the experimental stage and during completion thereof, any discovery shall continue the sole property of the discoverer. This shall be his reward."

Under questioning by Senator Johnson, he repeated his theory that the adrenal hormone was a stabilizer that would control tissue growth, causing a destructive effect upon malignant tissue, producing a peculiar type of necrosis "heretofore unknown," and without destruction of normal tissue.

Dr. Coffey continued (Report of Committee, page 6, line 10): "We discovered this active principle through a process created by ourselves. When we injected the extract in small doses of from 1 drop up to 15 or 16 drops, in the course of our experimental work, we found that most cases were using opiates for relief, and immediately thereafter were relieved of pain and after two or three injections, the pain entirely

disappeared, and in from 24 to 48 hours the cancer began to slough. That has already taken place in over 1,300 cases that we have injected and all those cases were inoperable. We use our extract in different types of cancer and likewise in sarcoma."

After recess the questioning was resumed.

Senator Johnson: "There is no claim on your part that you have found a cure for cancer?"

Dr. Coffey: "No, sir. I want it distinctly understood that we do not claim a treatment or cure for cancer [page 11, line 18]. Patients came by hundreds and likewise to our department in Los Angeles, until they reached 1,300 injections a day. Now it is impossible for us in an experimental way to conduct this thing in an orderly manner, and something must be done by the public press. I call attention to these poor unfortunate people who are grasping at straws—flocking to California in the hope that this is a cure. We feel that it is wrong on our part even for a second to encourage them. We are offering this as a theory. We believe it is a success, but it is for the scientific gentlemen to demonstrate its use and it will require a large expenditure of money, granting our theory is correct."

Then Senator Jones took up the questioning: "Now isn't this the result, that you get only persons in rather extreme stage?"

Dr. Coffey: "Absolutely. If we see a case can be operated upon, we refuse to give injection. If we, from our years of experience, see that radium will do that man any good, we refuse."

Senator Jones: "Have you ever treated any of the earlier stages of the trouble?"

Dr. Coffey: "We refuse to treat any of the earlier stages as an experiment. We have no right to do that scientifically. We must prove our position before we have the right to offer this as a cure or treatment. We follow usage and the scientific use of the knife, X-ray, and radium."

Following Dr. Coffey, others were questioned on the general idea of governmental aid for all research in cure of disease. Dr. Joseph C. Bloodgood, Dr. C. C. Little, and Dr. James Ewing emphasized the need of the passage of years before a conclusion regarding any cancer treatment could be reached. Dr. Ewing advised the Government to put less stress on the elusive cause of cancer and more time and financial aid on radiation facilities for treating the cancer cases already in the country.

In conclusion, regarding the Coffey-Humber Hospital release, we feel that the broadcast of early undue publicity has lessened confidence in all cancer treatment. There are a score of good men, including the leading cancer specialists, who have investigated and who express nothing but profound disappointment with both the clinical and pathological results of the Coffey-Humber injections. Postmortem examinations, which have been made in at least thirty cases, do not reveal any definite specific destruction of cancer tissue or evidence that the spread of cancer in the bodies of the afflicted patients has been retarded. There has evidently been too much Sunday supplement emphasis, or perhaps the combination of a chief surgeon and a superintendent of a railroad hospital may have made the press contacts too hard to control.

ALDEN WILLIAMS, M.D.

THE PROGRESS OF SURVEY OF RADIOLOGY

By the American Medical Association

The questionnaire which was prepared by leaders in radiology was sent out to a mailing list of 1,654 persons representing that specialty. A total of 1,150 questionnaires have been filled out and returned.

The Council on Medical Education and Hospitals, which was asked to do this work,

is now tabulating the returns, after which it will publish its report, and will also prepare a tentative list of directors of approved radiological laboratories. The "Essentials," which have been prepared by representative leaders in the field, have accompanied each questionnaire sent out.

All who have not sent in the questionnaire should do so. Additional blanks will be furnished by the Council on Medical Education and Hospitals of the American Medical Association, 535 North Dearborn Street, Chicago.

COMMUNICATION

To the Editor of RADIOLOGY:

Dear Doctor:—In reading over the various American and foreign journals in the field of radiology, I notice that a variety of symbols are used to express the recently adopted unit of X-ray intensity; this in spite of the fact that the terminology is clearly defined in the report of the Second International Congress of Radiology.

For example, most writers speak of applying so many "r-units." In ordinary physical practice, the unit of resistance is the ohm and its symbol is r or $\sim$. When speaking of the resistance of a coil of wire it is correct to say so many "ohms," but never so many "$\sim$-units" or so many "ohm units." Likewise we speak of so many "volts" but never so many "v-units" or "volt units." In writing the above terms it is correct to use "52$\sim$" or "38 V" but never "52$\sim$-units" or "38 V-units."

Thus, to be in keeping with physical practice and the international definitions we should speak of so many "roentgens" and write, for example, "100 r" and not "100 r-units" or "roentgen units."

In future publications from the Bureau of Standards the correct nomenclature will be observed and I feel that this should be brought to the attention of radiologists so that in the future we may have a uniform terminology in the literature.

Another question of terminology was also brought to my attention through the Bureau's editorial board. "Constant potential," as the term is usually used, rarely refers to true constant potential since all commercial X-ray equipment coming under such a head is quite far removed therefrom. (So far as I am aware, Prof. Duane has the only true constant potential X-ray generator, his being a storage battery.)

A national committee on electrical definitions has tentatively adopted the term "ripple potential" to describe such voltages as are produced by the ordinary kenotron-condenser rectifiers. The terms "ripplage" and "ripplance" will be used to express the amount of variation from true constant potential. The complete definitions of these terms will be given in a paper which is now in the press.

Respectfully,

LAURISTON S. TAYLOR.

Washington, D. C.
May 1, 1930

THIRTY-FIFTH ANNIVERSARY OF DISCOVERY OF THE ROENTGEN RAY

The Chicago Roentgen Society commemorated the thirty-fifth anniversary of the discovery of the X-rays by William Conrad Roentgen, at a dinner meeting held at the Lake Shore Athletic Club, May 8, 1930, at which about ninety were present.

The speakers of the evening were: I. Seth Hirsch, M.D., New York City, "Eulogy on Roentgen"; I. S. Trostler, M.D., Chicago, "Original Communication of the Discovery of X-rays by Roentgen"; William Allen

Pusey, M.D., Chicago, "The Pioneer Development of Radiation Therapy"; Paul B. Batty, Chicago, "The Electrical Engineer and the Physicist: Pioneer Work in Electrical and Mechanical Development of X-ray Apparatus." Charles B. Reed, M.D., Chicago, President of the Chicago Medical Society, acted as toastmaster and spoke on "The Relation of Radiology to General Medicine." The Chicago Roentgen Society was favored with a letter of congratulation from President Hoover and a telegram from Louis L. Emmerson, Governor of Illinois, copies of which follow.

[LETTER]

April 25, 1930.

Chicago Roentgen Society
Chicago, Illinois

My Dear Friends:

I cordially commend the celebration of the discovery of the roentgen ray, for it is one of the beacon lights of that steady progress by which science is enlightening the darkness of the unknown and guiding mankind ever forward into new knowledge and mastery of Nature.

Yours faithfully,
[Signed] HERBERT HOOVER.

[TELEGRAM]

April 29, 1930.

Chicago Roentgen Society

In extending to you my greetings on the celebration of the thirty-fifth anniversary of Roentgen's discovery of the roentgen ray I congratulate you on your vigorous efforts toward vitalizing the memory of this great scientist, who has bequeathed to mankind everlasting benefactions of immeasurable magnitude. His discovery of the X-ray has made available a means of therapy and an aid to diagnosis that no reputable doctor or dentist is willing—or even permitted—to ignore or neglect. That courts of justice freely grant to plaintiffs large sums in damage when evidence indicates professional neglect of X-ray usage, which apparently has resulted in extended physical suffering or deformity, suggests the indispensable character that X-ray equipment has assumed in the field of medical practice.

LOUIS L. EMMERSON, *Governor.*

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION

The officers for the Section on Radiology, American Medical Association, for the coming year are as follows: *Chairman,* Arthur W. Erskine, M.D., Cedar Rapids, Iowa; *Vice-chairman,* Ralph S. Bromer, M.D., Philadelphia, Pa.; *Secretary,* G. W. Grier, M.D., Pittsburgh, Pa.; *Executive Committee,* M. J. Hubeny, M.D., Chicago, Ill., F.M. Hodges, M.D., Richmond, Va., and Arthur W. Erskine, M.D., Cedar Rapids, Iowa. The *Section delegate* is James T. Case, M.D., Chicago, Ill., and the *alternate Section delegate* is W. W. Wasson, M.D., Denver, Colorado.

ABSTRACTS OF CURRENT LITERATURE

AUTHOR INDEX TO ABSTRACTS IN THIS ISSUE

SUBJECT INDEX

ARTHRITIS

A Clinical Study of Chronic Arthritis. Emil G. Vrtiak and Edwin P. Jordan. Jour. Am. Med. Assn., March 22, 1930, XCIV, 863.

Many others have concentrated on only one or two phases of this problem, *e.g.*, basal metabolism, sugar tolerance, and relation to focal infection. The authors have examined from as many angles as possible the clinical records of a group of patients with chronic arthritis. They have used Goldthwaite's classification, dividing their patients into three groups: hypertrophic arthritis (ostearthritis), atrophic arthritis (rheumatoid arthritis or arthritis deformans), and infectious arthritis. The latter is not clinically characteristic, and, radiologically, shows no bony changes.

No definite relationship between the menopause and chronic arthritis was apparent. A history of rheumatic disease in the family and the history of typhoid occurred often enough to warrant more detailed investigation. Secondary anemia was frequent in infectious arthritis, while an erythrocytosis was common in the hypertrophic form. Leukocytosis was a usual occurrence in infectious arthritis, but leukocytosis and leukopenia occurred with about equal frequency in the hypertrophic type. A questionable tendency towards a plus metabolic rate was found in the infectious, and towards a minus rate in the hypertrophic type of arthritis. A percentage of positive Wassermann tests, slightly higher than that usually found in similar age groups of non-arthritic persons, was found.

Foci of infection were found in a high percentage of patients with infectious or hypertrophic arthritis. In many, treatment of these foci resulted in marked improvement, while some patients became much better in the face of unremoved foci of infection.

C. G. SUTHERLAND, M.D.

BONE DISEASES (DIAGNOSIS)

A Critical Survey of Charcot's Arthropathy: Analysis of Eighty-eight Cases. Udo

J. Wile and Milton G. Butler. Jour. Am. Med. Assn., April 5, 1930, XCIV, 1053.

In their study the authors tabulate their observations to show a definite relation to the following eleven factors: age of onset, sex, joint involved, history of pre-existing syphilis, duration of syphilis previous to the onset of the joint involvement, means of establishing the diagnosis, incidence of trauma, associated spinal fluid reactions, type of cerebrospinal disease present, roentgen observations, and, finally, additional associated data.

A comprehensive survey of all these factors in a series of about eighty-eight cases thoroughly reviews the subject.

C. G. SUTHERLAND, M.D.

Articular Chondromatosis. Ettore Conte. La Radiologia Medica, March, 1930, XVII, 237.

The author states the difficulties confronting the diagnosis of this disease. With the aid of the radiological and clinical data supplied by his personal experience, and that offered by the medical literature, he gives a complete sketch of this morbose process. He establishes its differential characters from both the etiological and clinico-radiological viewpoints, especially in comparison with arthritis deformans, which seems to be the affection more frequently confused with articular chondromatosis.

L. MARINELLI.

BONE TUMORS (DIAGNOSIS)

Ewing's Sarcoma: Small Round-cell Sarcoma of Bone. Murray M. Copeland and Charles F. Geschickter. Arch. Surg., February, 1930, XX, 246.

There is a foreword on this article, written by Dr. Joseph C. Bloodgood, in which he gives the benefit of his experience in bone tumors in general, and this tumor in particular. The authors have reviewed all of the bone tumors of the Johns Hopkins Hospital, representing something over 1,500 cases.

Ewing's sarcoma was found to be essentially a disease of early life, 95 per cent of the cases in this series occurring in persons between the ages of four and a half and twenty-five. Among the 400 sarcomas in this series, 15 per cent were found to be Ewing's sarcoma. Pain was an outstanding symptom in 83 per cent of the cases, and was noted as the first symptom in 35 per cent. It varied from a tenderness or soreness to continuous pain, either dull aching or sharp shooting pain. In 90 per cent of the cases a mass could be palpated, and in 19 per cent a swelling was complained of as the initial symptom. On palpation the majority of the tumors presented an indurated swelling, with a surface ranging from rough and irregular to smooth, and totally immobile, apparently continuous with the bone. The bones involved in the greatest number of cases have been the tibia, femur, fibula, humerus, pelvis, and scapula, and in smaller numbers in many other bones. Pathologic fracture was of relatively rare occurrence in this series.

Fever was noted in a number of these cases. The blood examination revealed no findings significant in this condition. Many of the patients showed very little change in nutrition until the terminal stages of the disease. Internal metastases usually presented themselves clinically late in the disease.

The roentgen-ray studies revealed that the earliest stages of the lesion presented the most difficulty in diagnosis. In the early cases, there was a slight expansion of the shaft, with a periosteal reaction looking somewhat like onion peel. The cortex of the shaft appeared thickened, with some mottling in the region of the medullary cavity, due to areas of increased density. Later in the disease, there was considerable extension of the tumor along the shaft. The medullary cavity often showed osteoporosis, and the cortex showed evidence of destruction. There were varying degrees of periosteal reaction, and a characteristically increased density of the bone in the region of the widened cortex. Osteophytes arranged irregularly or at right-angles to the cortex occasionally appeared in the picture. In a number of the early cases, the first evidence of tumor formation was given by an increase in density of bone.

The gross examination of the tumor showed that, with one exception, its bulk lay subperiosteally. The medullary cavity sometimes contained a small portion of the tumor, but, usually, this region was constricted or totally occluded by new reactive bone. When the involvement of the bone was diffuse, subperiosteal formation of new bone was both parallel and at right-angles to the cortex. Due to the growth of the tumor and subsequent hemorrhage, there was a gradual separation of the periosteum from the underlying cortex. The parallel deposits of new bone appeared to be the result of proliferation of the peripheral layer of the cortex when the periosteum had suffered minute separation from the bone. This gave the onion-peel-like formation characteristic in roentgenograms of the early stages. With increased separation of the periosteum, spicules of new bone from the subperiosteal region are laid down at right-angles to the shaft rather than parallel. This is due to the blood vessels perforating Volkmann's canals which determine the direction of the new growth of bone when they are pulled outward in maintaining their continuity after the periosteum has been elevated. The two types of formation of bone, parallel and radiating, duplicate the process observed in the embryo. The microscopic examination revealed a more or less constant cellular picture. There was a small polyhedral cell with a round or oval nucleus. The cytoplasm was scanty and did not stain well. The nucleus was deeply stained, showing a definite limiting membrane. Nucleoli were rarely seen, but mitotic figures were not infrequently noted. There appeared to be no intercellular stroma, but the tissue was divided into lobules by a fibrous trabeculation. Various other microscopic changes were found which will not be gone into in this abstract.

The most frequent sites of metastases were the lungs, lymph glands, and the skull. The spine, scapula, and clavicle, however, were also frequently the sites of metastases.

In differential diagnosis, many other conditions must be considered, especially inflammatory disease of bone. In ten cases the diagnosis of pyogenic periostitis or osteomyelitis was made; in nine cases, tuberculosis of bone; in six cases, syphilitic periostitis or osteomyelitis, and in one case, typhoid osteomyelitis. Clinically, multiple myeloma was noted as the source of confusion in two of the cases of Ewing's sarcoma. Osteogenic sarcoma must also be differentiated from this condition, as well as metastatic carcinoma.

In the treatment of this condition, the authors believe that in cases in which metastases have not occurred, amputation for lesions in the lower extremity below the upper third of the femur, and resection of bone for lesions in the upper extremity, followed by post-operative irradiation, offer more hope of cure than does irradiation alone. If the lesion occurs in the upper portion of the femur or has become extensive, irradiation should be resorted to and continued in therapeutic doses until amputation becomes a necessity to relieve pain.

Out of 52 cases of Ewing's sarcoma, eight are living and are apparently well. All of these patients are over five years, and the average duration of life is seven years and eight months for the eight cases. In one group of 13 cases which had amputation with irradiation, there was a post-operative duration of life averaging 29.2 months. In three cases in this group, the patients were found to be well, with an average duration of life of five years and seven months. In another group which had amputation without irradiation, there were 24 cases, with an average duration of life of twenty months. In four cases in this group, the patients are well, with an average duration of life of six years. In the third group, which had irradiation alone, there are eight cases, with an average duration of life of 27 months, and in one case in this group, the patient is living 53 months after treatment.

Coley's toxins apparently have had no effect on the duration of life, whether given alone or with other forms of treatment.

Exploration does not ordinarily affect the prognosis in which radical operation or X-ray treatment follows exploration. In two cases, or 25 per cent, in which the patients are living over five years, exploration was done before resorting to operation.

HOWARD P. DOUB, M.D.

CANCER (DIAGNOSIS)

Primary Adenocarcinoma of the Jejunum, with a Report of Two Cases. Francis C. Newton and Richard C. Buckley. New Eng. Jour. Med., Feb. 6, 1930, CCII, 255.

Two examples of primary adenocarcinoma of the jejunum are reported. These were similar in location but produced different clinical symptoms. In the first patient, the chief symptom was a severe and unexplained secondary anemia. Ulcerated carcinoma of the jejunum was an unexpected finding at autopsy. In the second patient, high intestinal obstruction occurred and the diagnosis was made by X-ray examination. A tumor was resected and within a short time retroperitoneal metastases were found.

W. W. Watkins, M.D.

The Relationship between the Clinical and Pathological Findings in Primary Pulmonary Malignancy. Ralston Paterson. Can. Med. Assn. Jour., March, 1930, XXII, 333.

Carcinoma of the lung is a rapidly progressive disease, the average duration being about six and one-half months. During this period the pathologic processes show a number of characteristic changes, and with these are associated characteristic radiologic and clinical findings.

Classified from the standpoint of foci of origin, lung malignancy is subdivided into bronchial and parenchymal. Bronchoscopy is the diagnostic agent of choice in the bronchial type.

Bronchial growths are not visualized early from the roentgenogram. When the shadow does show it will always be unilateral and of an infiltrating nature. If the growth is chiefly intraluminal and tends to obstruct the bronchus, the roentgenologic picture is characteristic, being an atelectasis of the part of the lung shut off.

The first symptom of the bronchial type of growth is cough, associated later with hemoptysis. Secondary infection is followed by bronchiectasis peripheral to the lesion, with sputum and fever.

Growths of the parenchymal type have their primary focus within the lung substance or from the wall of a minor bronchus. They are demonstrated easily on the X-ray film as irregular nodular masses in the lung fields. Later the growth involves a bronchus, and atelectasis is added to the picture. Later still the pleura is involved and pleural effusion is added. The symptoms of this latter type are, first, a deep-seated chest pain, with, later, cough and bleeding. With pleurisy and infection supervening, there is added fever and toxemia.

L. J. Carter, M.D.

Notes on the Etiology of Cancer. Albert Soiland. Am. Jour. Surg., March, 1930, VIII, 654.

The author gives a very thorough dissertation on the influence of mechanical irritation on the production of cancer, and concludes that the importance of this has been greatly over-estimated. He considers that other factors must be present in addition to the irritation in order to produce cancer. The work of Dr. Maud Slye on the hereditary theory would appear to be an outstanding contribution to the work on the etiology of cancer.

The author brings up several other points to be considered: First, the types of cancer under discussion show a predilection for a junction point of two epithelial structures; second, the combined action of constant irritation and physiological function at this point brings on early senility of the cells in these parts so as to invite cancer development.

Finally, there seems to be a tendency to turn toward the endocrine system, which may after all be the sole custodian of the secret.

H. P. Doub, M.D.

Primary Lung Tumor: Report of Six Cases with Necropsies. Lila M. Bonner. Jour. Am. Med. Assn., April 5, 1930, XCIV, 1044.

Primary cancer of the lung is the basis of this essay, and a report of six cases with

necropsies is made. The literature is reviewed, with a discussion of the etiology and pathology of the disease. The duration of the disease in the cases presented was from four months to three years. One occurred with a lung abscess—lung abscess has been commonly found in conjunction with cancer of the lung.

The cardinal symptoms of early primary lung tumor are pain, dyspnea, cough, sputum, and fever. Persistent pain in a person of the cancer age should always call to mind the possibility of a hidden malignant condition.

Surgery offers the only hope of cure. Roentgen irradiation may give marked temporary palliation, but disappointing end-results.

C. G. SUTHERLAND, M.D.

CANCER (THERAPY)

Carcinoma of the Prostate. George Gilbert Smith. New Eng. Jour. Med., April 17, 1930, CCII, 756.

Cases of cancer of the prostate fall into three classes. In Class A, the growth is confined within the capsule of the prostate and total prostatectomy is the procedure of choice. In the author's series of 65 cases, 29 were in this class. In Class B, the growth has extended beyond the prostatic capsule, but does not show evidence of metastases; treatment should be by insertion of radium needles or seeds into the gland; 17 of the 65 patients were in this class. In Class C, metastases have developed. Palliative treatment is best given by high voltage X-ray; of the 65 cases, 19 were in this class.

W. W. WATKINS, M.D.

Carcinoma of the Uterus—Its Treatment by Radiation. Albert Soiland and William E. Costolow. Calif. and West. Med., February, 1930, XXXII, 95.

The authors use the grouping advised by Schmitz in the diagnosis of uterine carcinoma. Studying statistics, they note that surgical results on carcinoma of the cervix are extremely poor, even from the most radical operation. From the clinics of the best operators the five-year cures amount to less than 20 per cent.

Increasing attention has recently been given to the consideration of the type of cell in the particular growth, and to the question of radiosensitivity. For many years it has been noted that cervical carcinoma has varied in its response to radiation. Where the conditions clinically appeared similar, and were treated by the same technic, it has been observed that the response in one case would be slow and uncertain, while in other cases the disease would melt away rapidly and completely. It is now known that this is largely due to a difference in radiosensitivity of the cells. The practice is now to classify the carcinomas according to cell type.

Regarding the technic of the treatment, the author's procedure is to give 3,500 mg. el hrs., 60 per cent of which is placed against the cervix and filtered with two millimeters of gold and one millimeter of rubber. The other 40 per cent is placed within the uterus, filtered with one millimeter of gold and one millimeter of rubber. Three weeks later, 3,000 mg. el hrs. are given with the same type of applicator. No further radiation should be given in the next six to twelve months.

The patient is observed at monthly intervals, and late recurrences, appearing a year or so after the original therapy, are often treated with small doses of radium applied locally, although great care is exercised. Often suspiciously thickened areas remain for several months and finally disappear. These areas should not be treated unless they are of definite malignancy. Experience in observation is a most valuable asset at this stage of the treatment.

In the treatment of carcinoma of the fundus the authors use combined radium and roentgen-ray treatment. A total dosage of 4,000 to 5,000 mg. el hrs. of radium, filtered by one millimeter of gold and one millimeter of rubber, is applied intra-uterine. This is followed by deep roentgen-ray therapy in about two weeks.

Roentgen-ray therapy should be combined with radium in all cases of uterine carcinoma,

unless contra-indicated by the poor general condition of the patient. Advanced cases of carcinoma of the fundus uteri should be treated by radiation alone. It seems possible that results may be obtained by radiation in early cases of carcinoma of the fundus, which will equal the present surgical results. Carcinoma of the cervix uteri is no longer a surgical condition and should be treated by radiation alone.

F. B. Sheldon, M.D.

Rodent Ulcer. Richard L. Sutton, Jr. Jour. Missouri St. Med. Assn., March, 1930, XXVII, 103.

The term "rodent ulcer" is not scientifically used; it is frequently used either for basal-cell or prickle-cell carcinoma of the skin, although there is a marked clinical and histopathologic difference in these two growths. After a thorough discussion of the various types of lesions which are sometimes called "rodent ulcer," and also a discussion of the various methods of treatment, the author concludes that the term "rodent ulcer" should be discarded, and the correct term, based on histopathology, should be substituted. Treatment should consist in the extinction of the neoplastic cells in the manner which will give the best cosmetic results. Irradiation is the method of choice, and as between X-ray and radium, the latter is preferable, on account of the accuracy with which the dose may be applied.

W. W. Watkins, M.D.

On Radiation Effect and Radiation Dosage Based on Observations in Uterine Carcinoma, with Pre-operative Irradiation. W. Lahm. Strahlentherapie, 1930, XXXVI, 237.

The examination of cervical carcinoma through the vaginal speculum does not give an accurate idea of the extension of the process. A number of illustrations showing the cervical os as seen through the speculum and in the sagittal section explain this point. It is difficult, if not impossible, therefore, to learn from the study of an excised cervix which had been previously irradiated, how much of the tumor was destroyed by the rays. Macroscopic and microscopic studies of a series of patients who had been treated by roentgen rays and radium demonstrated that only the tissue infiltrated by carcinoma was destroyed. No explanation can be given so far for this observation. It is possible that the limited destruction is due to a definite sensitivity of the diseased part, or it may also be possible that the necrotic carcinoma forms a cytolytic substance. A discussion of the problem of dosage pertaining to carcinoma of the cervix and metastasis in the parametrium follows, which is supplemented by a number of case histories.

Ernst A. Pohle, M.D., Ph.D.

Malignancy of the Oral Cavity. C. M. Hamilton. Jour. Tennessee St. Med. Assn., March, 1930, XXIII, 79.

Cancer of the mouth is curable, but, to obtain the best results, it is necessary to start treatment early. Palliation and insufficient treatment are worse than none. Proper combination of methods offers the most success. Every case presents the double problem of the local lesion and the lymph drainage areas. The local lesion can be removed by excision, cauterization, electrocoagulation, or radiation. The dual procedure of electrocoagulation and radiation is more effective in destroying the local lesion than either method singly. Treatment of the lymph glands is more important than treatment of the local lesion. The result in unselected cases varies from 15 to 60 per cent with different authorities. Cancer of the tongue and floor of the mouth are the most unfavorable, while epitheliomas of the alveolar ridge and hard palate offer better prognoses.

W. W. Watkins, M.D.

THE CHEST (DIAGNOSIS)

Interpretation of Roentgenograms of the Chest in Children Based on Observations at

Necropsy: III.—Diseases of the Lungs, of the Pleura, and of the Mediastinum. John A. Bigler. Am. Jour. Dis. Child., January, 1930, XXXIX, 91.

Correlation of 171 necropsy and roentgen-ray examinations of the lungs is attempted. Bronchopneumonia was more common and the pleural involvement was less common than in lobar pneumonia. Two cases of congenital laryngeal stridor gave no roentgen-ray findings other than the general picture of emphysema. Pleural adhesions were found more often by the pathologist than by the roentgenologist.

In pneumothorax and pyopneumothorax necropsies showed connection with a bronchus. The author states that these conditions occur frequently following pleural puncture, both diagnostic and therapeutic. The hilum shadows and linear markings are made up mostly by blood in the blood vessels and not by the bronchi. Normal lymph glands do not cause shadows. Hypoplastic lymph nodes, either caseated or inflammatory, cannot be recognized if they do not contain calcium. The size and shape of the hilum shadows are not influenced by active infection alone, but by previous infections.

A number of roentgenograms, illustrating lung and mediastinal pathologic change confirmed by necropsy, were included.

F. B. Mandeville, M.D.

Massive Collapse of the Lung. H. H. Murphy. Can. Med. Assn. Jour., March, 1930, XXII, 327.

Massive collapse of the lung is a condition in which the lung, without the presence of any gross lesion, such as bronchial obstruction, pleural adhesion, etc., interfering with the free entry of air, becomes airless to a greater or lesser degree. It occurs most frequently after operative treatment for inguinal hernia or appendicitis. It may involve a lobule, a lobe, one entire lung, or even both lungs.

The important causes are a combination of three conditions, namely, a thick pleural exudate, viscid bronchial secretion, and some suppression of the cough reflex.

From the standpoint of symptomatology there are two types of cases, depending on the presence or absence of pneumonia signs.

The physical signs are: displacement of the heart to the affected side, and depression of the chest wall, with the usual signs of consolidation.

The atypical case may escape detection if a bedside radiographic examination is not made. The radiographic evidence is clear and unmistakable.

Two of the author's interesting cases are reported.

L. J. Carter, M.D.

Infection of the Upper Respiratory Tract as an Etiological Factor in Pulmonary Disease. I. R. Smith. Can. Med. Assn. Jour., February, 1930, XXII, 194.

The object of this paper is to show the important rôle played by upper respiratory tract infections in the etiology of pulmonary disease. The removal of such gives excellent results.

Analysis is made of 1,510 cases where pulmonary complaints were the leading feature. The common symptoms were: cough, postnasal discharge, loss of weight, general weakness, rise of temperature on exercise, expectoration, dyspnea, and anemia. Of this whole group 166 proved to be tuberculous. The major portion of the remainder was diagnosed as cases of bronchitis, bronchiectasis, or asthma. These were divided into seven groups, according to the presence or absence of one or more of the following: clinical chest findings, X-ray chest findings, and upper respiratory findings, including sinuses, nose, and throat.

In three of the groups clinical chest findings were absent; in three, X-ray findings were absent, and in three, upper respiratory findings were absent.

The radiographic findings group themselves into three classes: (1) enlarged nodes in indefinitely enlarged hilum shadows, with thickening of the lower bronchial tree; (2) thick-

ening of the upper bronchial tree, and (3) a combination of (1) and (2).

The associated upper tract diseases found were: deviation of septum, hypertrophied turbinates, sinus disease, nasal mucous membrane ulceration, diseased tonsils, adenoids, pyorrhea, granular pharynx.

The author emphasizes the great importance of collaboration between the laryngologist, the internist, and the radiologist in the diagnosis.

L. J. CARTER, M.D.

The Roentgenological Aspects of Empyema. Ralston Paterson. Am. Jour. Surg., March, 1930, VIII, 638.

The author advises a very thorough fluoroscopic examination of the chest in all possible positions in order to accurately determine the exact position and extent of the lesion. This is then followed by films made in several positions which have previously been found, fluoroscopically, to show the fluid to the best advantage.

The roentgenologic appearances produced by free effusions in the pleural cavity are discussed, and these are compared with the appearances of true purulent effusions. With free fluid there may be a slight change in its distribution with changes of posture, but, with true pyogenic exudate, there is very little alteration in the fluid level with changes of posture, owing to the fact that both the parietal and visceral pleura are coated with thin layers of fibrinous exudate, which tend to fusion at the edges.

The fluid shadows must be differentiated from consolidation of the lungs, malignancy, and atelectasis. The greatest difficulty encountered, however, is a co-existence of fluid with pneumonia or malignancy.

Encapsulated effusion may form in relationship to any portion of the surface of the pleura, superficial or deep. This must be differentiated from lung abscess, plaques of dense pleural thickening arising as residues of old empyemata, and benign or relatively circumscribed malignant tumors of the pleura.

If, for any reason, an empyema becomes chronic, with multiple pockets, simple chest roentgenograms will frequently not tell the whole story. Injections of these sinuses and pockets with lipiodol or some other opaque medium is often of great value.

H. P. DOUB, M.D.

Acute Mediastinal Abscess. B. J. Malnekoff. Am. Jour. Dis. Child., March, 1930, XXXIX, 591.

Acute mediastinal abscess is rare in infancy and childhood. A case of an infant twenty-one months old is presented. Twelve days after the onset of upper respiratory symptoms a roentgenogram of the chest was negative. Three weeks after the onset of symptoms a roentgenogram showed a shadow of increased density in the right upper chest, apparently continuous with the mediastinum and presenting a fairly well rounded outer border. Fluoroscopy and films at another examination showed a dense shadow in the anterior mediastinum outside of the lung.

Measles and otitis media were complicating factors in this case. The von Pirquet test and blood cultures were negative.

Repeated aspirations in the third right intercostal space anteriorly, just adjacent to the sternum, were made, and 45 c.c. of thick grayish pus containing streptococci and pneumococci was obtained. Ultra-violet therapy was also used.

The author concludes that the mediastinal abscess was due to encapsulation of suppurating tracheobronchial lymph glands draining the upper respiratory tract.

F. B. MANDEVILLE, M.D.

The Roentgen Findings in Atypical Influenza Pneumonias. Georg Peschel. Röntgenpraxis, April 1, 1930, II, 315.

During the influenza epidemics of the last few years the author frequently observed atypical pneumonias, which presented considerable diagnostic difficulties. Extensive pneumonias were seen with very few and slight clinical symptoms. The chronic condi-

tion resulting can easily be confused with a cirrhotic tuberculosis, syphilis of the lung, or many forms of bronchial carcinoma. In other cases the differential diagnosis from an early tuberculosis could not be made roentgenologically. Miliary bronchopneumonias were seen occasionally, which simulated the appearance of miliary tuberculosis. When confronted with the picture of a so-called healed miliary tuberculosis, one should think of the possibility that it may be the resulting stage of miliary bronchopneumonia as seen in influenza.

H. W. HEFKE, M.D.

Pleurisy in Infants and Children: Radiologically Demonstrated. E. Gordon Stoloff. Am. Jour. Surg., March, 1930, VIII, 662.

The author discusses acute pleurisy together with effusion and gives the ordinary roentgenological findings as usually described.

He then describes empyema together with the various types of encapsulated fluid, depending upon their location and the structures with which they are in contact. He states that encapsulation of purulent fluid is common in the earlier years of life and may be situated in almost any portion of the chest, including the mediastinum. He combines fluoroscopy with films in various positions in the diagnosis of these conditions.

There is also a chapter on the topography of the fissures and lobes of the lungs, together with points in roentgen diagnosis.

This article is written in text-book form and is difficult to condense into a small space.

H. P. DOUB, M.D.

Bronchiectasis. Alton Ochsner. Am. Jour. Med. Sci., March, 1930, CLXXIX, 388.

This is a fairly exhaustive study of the subject, with an excellent bibliography. The author states that bronchiectasis is one of the most frequent chronic pulmonary affections. Chronic bronchitis, influenza, and nasal sinusitis are the most frequent causative agents. Text-book descriptions represent late stages of the condition. The early diagnosis can be made only by X-ray, following intratracheal introduction of iodized oil for outlining the tracheobronchial tree. The repeated introduction of this oil is of distinct therapeutic value. The results of 1,500 bronchographies are reported. One hundred and twelve cases were treated, and of these 32 per cent were symptomatically cured.

W. W. WATKINS, M.D.

CIRCULATORY DISTURBANCE

Volkmann's Ischemic Contracture. Henry W. Meyerding. Jour. Am. Med. Assn., Feb. 8, 1930, XCIV, 394.

The disastrous complication of injury which produces contracture of the flexor muscles of the fingers, wrist, and forearm, described by Volkmann in 1869, interests every practising physician. The descriptive term "ischemic contracture" is preferred by Meyerding. The condition is a deformity, usually of the forearm, wrist, and hand, with or without paralysis. It complicates trauma, usually fracture, and produces varying degrees of disability. Injury to muscle cells from interference with circulation, and degeneration of muscle as a result of toxins produced by venous stasis have been advanced as etiologic factors. Thomas held circulatory disturbance in itself as insufficient, emphasizing nerve involvement. Jepson's experimental studies demonstrated that a combination of factors is concerned. Early operation, as a preventive measure, is of great value in insuring normal function. Careful, early, and repeated inspection, with relief of undue intrinsic and extrinsic pressure, may prevent disastrous results. The physician should be on his guard to see that malposition, hematoma, flexion splints, and bandages do not impair circulation. Diagnosed a few hours after its occurrence, treatment of the fracture should be abandoned and all attention paid to improvement of the circulation. Conservative treatment, consisting of gradual extension and physical therapy, gives excellent results. Long-standing, severe cases may require surgical intervention, such as tenoplasty, arthrodesis, or neurolysis.

C. G. SUTHERLAND, M.B. (Tor.)

DIAPHRAGMATIC HERNIA (DIAGNOSIS)

Diaphragmatic Hernia. Robert Lee Sanders. Ann. Surg., March, 1930, XCI, 367.

Sisk computes that approximately a thousand reports of cases of diaphragmatic hernia have been published since 1920. Prior to the use of the roentgen rays, cases were seldom diagnosed until operation or necropsy. The general symptoms are at best bewildering. A history of trauma is not necessary, as congenital types are manifested at any age.

If developmental failure occurs before the membranous diaphragm is complete, the defect will be total and the thoracic and abdominal cavities will be in free communication. The hernia will be without a sac—the so-called "false hernia." Later, during the formation of the muscular diaphragm, a layer of apposed pleura and peritoneum will separate the cavities, and will form a sac for the ascending abdominal viscera. The first type is formed probably during intra-uterine life and the symptoms appear late. In the second, herniation may not take place until long after birth, and if small, it may never occur.

If no history of trauma or penetrating wound is obtained, the hernia is probably congenital. Hedblom believes the term "acquired" is preferable for hernias that take place slowly. Congenital and traumatic hernias are more frequent through the left half of the diaphragm. The author quotes a case reported by Jansen in which the entire right leaf of the diaphragm was absent.

The etiology of acquired types is discussed. Gunshot, shell, and stab-wounds of the diaphragm, compression of the thorax and epigastrium, with sudden increase in intra-abdominal pressure, accidental cutting during thoracic operations and rib-resections, are listed among the causes.

Until routine roentgen examination of every baby is made we shall not know how frequent congenital diaphragmatic hernia really is. Many cases are not diagnosed because symptoms are not severe and no examination is made.

Combined abdominal and thoracic approach probably expedites the operation and makes it easier and safer for the patient. Diaphragmatic hernias should be operated on, except cases of esophageal hiatus hernia, with a short esophagus, in which repair is impracticable. Repair is dangerous during pregnancy. In cases treated surgically, a 5 per cent recurrence is found by the author.

F. B. MANDEVILLE, M.D.

Non-traumatic Diaphragmatic Hernia. Joseph F. Elward and Laurence S. Otell. Am. Jour. Roentgenol. and Rad. Ther., December, 1929, XXII, 535.

While the patient with non-traumatic diaphragmatic hernia may be without symptoms, he is more apt to have symptoms closely simulating gall-bladder disease or ulcer, hence, the writers emphasize the necessity of care in excluding diaphragmatic hernia when ulcer and gall-bladder disease have been excluded. The theories of congenital abnormality in the development of the omental bursa or closure of the pleuroperitoneal membranes, as well as the theory of acquired hernia through oft-repeated intra-abdominal pressure, are discussed. In one of the cases the patient's symptoms became more marked following an attack of whooping cough. While commonly such hernias are through the esophageal hiatus, they may be anterior, central, or posterior, one of the cases reported being that of a portion of the transverse colon through the central opening. The authors' six cases occurred in a series of approximately 400 gastro-intestinal studies.

J. E. HABBE, M.D.

Diaphragmatic Hernia: Phrenic Nerve Stimulation under Fluoroscope as an Aid in Diagnosis. Richard H. Overholt. Ann. Surg., March, 1930, XCI, 381.

There are six diagnostic methods of value in establishing a differential diagnosis between diaphragmatic hernia and eventration. They are, namely, movements of the costal margins,

roentgenoscopic signs, intragastric pressure signs, pneumoperitoneum, laparotomy, and faradization of the phrenic nerve.

A case of diaphragmatic hernia in a girl twenty-two years of age is presented. Two well known roentgenologists studied the case. Fluoroscopic and antero-posterior and lateral roentgenograms were obtained. The first made a diagnosis of eventration of the left dome of the diaphragm; the second called it a hernia.

A review of the literature in these two conditions is made by the author. The inaccuracy of some of the well known fluoroscopic signs, such as paradoxical movements, position and contour of the diaphragmatic domes, is discussed. The importance of fluoroscopic observation of a barium meal, and the need of repeated examinations are emphasized.

The author finds that faradization of the phrenic nerve and fluoroscopic observation of the dome of the diaphragm, at the same time, is of value in the differential diagnosis. In eventration, the faradization of the nerve fails to cause a contraction. In hernia, a response of the diaphragm can be seen under the fluoroscope.

F. B. Mandeville, M.D.

DIATHERMY

Therapeutic Fever Produced by Diathermy, with Special Reference to Its Application in the Treatment of Paresis. J. Cash King and Edwin W. Cocke. South. Med. Jour., March, 1930, XXIII, 222.

Since the introduction of malarial infection for the production of therapeutic fever in treating paresis, effort has been made to produce the desired temperature curves without giving the patient another disease, which is not always easy to eradicate. These authors describe the method of producing such temperatures by diathermy, using a specially designed apparatus capable of generating from 3,000 to 6,000 milliamperes. This is applied to the body by means of large 7 by 9 inch electrodes, the patient being wrapped in rubber sheets and blankets to prevent too rapid dissipation of the heat. The advantages of such a method are obvious; it is always available and under accurate control, no foreign organism is introduced into the patient, the desired elevations can be produced in all patients, and drug therapy can be used in conjunction. More than twenty patients have been treated so far, all with verified diagnoses of paresis. The results compare favorably with the malarial infection method.

W. W. Watkins, M.D.

DOSAGE

Radiosensitivity during the Reaction Period. Alessandro Vallebona. Atti del Raduno Radiologi Alta Italia, October, 1928, VI, 295.

This is a comparative study of skin erythemas produced by the same quantity of radium radiation given in one or two stages, and at different intervals. The skin reaction, due to fractional dosage, is always less pronounced, with the exception of the case in which the second application is given fifteen days after the first. The author, owing to the restricted experimental data, does not draw any final conclusions, but emphasizes the importance of administering fractional doses in the definite period of maximum sensitivity which follows the first treatment.

L. Marinelli.

Calculations of Tissue Dosage in Radiation Therapy: A Preliminary Report. Hayes E. Martin and Edith H. Quimby. Am. Jour. Roentgenol. and Rad. Ther., February, 1930, XXIII, 173.

The authors have studied a series of ten mouth and throat malignancies in which the size and location of the primary tumors and metastases could be determined with fair accuracy. They next attempted to determine exactly the amount of radiation delivered to the tumor, which, in most instances, was treated by combined gamma rays of radium

and high voltage X-rays, and to estimate in terms of "threshold erythema" doses the lethal or superlethal dose for the tumor. (The threshold erythema dose is that amount of radiation which in 80 per cent of the cases treated produces a faint reddening or bronzing of the skin in from 10 to 20 days, and in the other 20 per cent produces no visible effect.) For the several settings for X-ray treatment and the several radium applications used, depth dose charts are given. In most instances the lethal or superlethal dose was found to be in the neighborhood of from 8 to 10 erythema doses administered within from 2 to 3 weeks, hence the futility of attempting to cure such tumors as these by external irradiation alone.

J. E. HABBE, M.D.

Capillaroscopic Study of X-ray Erythema. Luigi Turano. La Radiologia Medica, February, 1930, XVII, 139.

The author could detect very important changes in the capillaries a few hours after the administration of the dose. They consist of rather irregular contractions and dilatations which probably correspond to the reddening waves studied by Miescher. The period of their appearance, their frequency and duration, depend upon the general characteristic of the subject treated and the dose given. A tendency to normal conditions is noted about two months after the treatment, and the visible dermal reactions are always preceded by capillaroscopic anomalies. The general behavior of X-ray erythema seems to confirm the belief of the author, namely, that the capillaries have an intrinsic nervous element, related to the sympathetic nervous system which, under radiation stimulation, has a mobility of its own.

L. MARINELLI.

ESOPHAGUS (DIAGNOSIS)

Cardiospasm in the New-born Infant. Louis H. Segar and Walter Stoeffler. Am. Jour. Dis. Child., February, 1930, XXXIX, 354.

Until recently, cardiospasm was thought to be a comparatively rare condition. Moersch at the Mayo Clinic, in a study of a series of 691 consecutive cases in children under fourteen years of age, found thirty-four cases. Messeloff found eleven more cases in the literature. Chevalier Jackson has reported one case in a new-born infant. Two case reports, with roentgenograms of cardiospasm in new-born infants, are presented by the authors.

There are numerous opinions concerning the etiology and pathology of cardiospasm. It may have a functional or an organic basis. Jackson's conception is that deglutition is normally controlled by pinch-cock action of the peri-esophageal diaphragmatic structures, especially the sphincterlike prolongations of the crura. There is a momentary relaxation of this pinch-cock action during deglutition, while at other times it prevents regurgitation of fluids from the stomach. The act of swallowing is a highly co-ordinated mechanism, and Jackson believes that some cases of "phrenoesophagospasm" may be due to disordered co-ordination in the deglutitory cycle.

F. B. MANDEVILLE, M.D.

Benign Lesions in Cardiac Portions of Esophagus and Stomach: Roentgenologic Diagnosis. Alexander B. Moore. Jour. Am. Med. Assn., Jan. 4, 1930, XCIV, 12.

That the cardiac segments of the esophagus and stomach constitute a rather unsatisfactory field for roentgenologic diagnosis is pointed out by Moore. Benign lesions in this field comprise chiefly cicatricial strictures, cardiospasm, diverticula, non-malignant newgrowths, ulcers, and diaphragmatic hernia. Syphilitic involvement of the esophagus is extremely rare in his experience, and of the cardiac end of the stomach usually by extension from the lower segments. Benign newgrowths of the esophagus are also rare and are uncommon in the cardiac portion of the stomach. Fundamentally, the diagnosis of hernia of the stomach rests on ascertaining the fact that at least a portion of the stomach is above the diaphragm.

C. G. SUTHERLAND, M.B. (Tor.)

EXPERIMENTAL STUDIES

The Radiation and Heat Reaction of the Skin. Third Communication. The Relation between Pigmentation and Protection against Heat Rays. Philipp Keller. Strahlentherapie, 1930, XXXV, 353.

In this third article, Keller reports the results of his experiments concerning the effect of pigmentation in the skin on the temperature increase following exposure to visible and infra-red heat rays. He comes to the conclusion that pigmentation does not offer a protection against heat rays. Blackening of the skin with India ink does not influence the temperature during irradiation. However, there is a definite difference between infra-red rays of long wave length, infra-red rays of short wave length, and visible rays. Following exposure to visible light, the surface temperature of the pigmented skin is increased, due to increased absorption. The effect of infra-red rays of long wave length is not influenced at all by pigmentation.

E. A. Pohle, M.D., Ph.D.

FOREIGN BODIES

Pneumotenon: A New Means of Demonstrating the Spatium Interfasciale Tenoni and the Posterior Sclera by a Combination of Contrast Media. Robert Sandera. Röntgenpraxis, Feb. 15, 1930, II, 175.

The difficulties in exactly localizing retrobulbar foreign bodies are emphasized, especially the fact that the foreign body may move with the bulbus. By injecting air and a small amount of lipiodol into Tenon's space, the bulbus itself could be demonstrated clearly, and the foreign body definitely shown to be outside the posterior sclera in the retrobulbar tissue.

H. W. Hefke, M.D.

A Simple Apparatus and Method for Readily Determining the Exact Location of Radiopaque Foreign Bodies in the Eye or Orbital Region, by Radiography. D. B. McGrigor. Brit. Jour. Radiol., March, 1929, II, 136.

The apparatus consists of an adjustable frame, similar to the ordinary spectacle-testing frame, which acts as a film holder and cross-wire cassette. With the patient supine and the head fixed, two postero-anterior exposures are made with the previously centered undertable tube being shifted 3 centimeters to either side of the central position in order to produce the shadow shift necessary for final calculations based on geometric triangulation.

The article is accompanied by graphs and charts to aid in a complete understanding of the method, but the author takes for granted that the reader has an understanding of the original Mackenzie Davidson method.

J. E. Habbe, M.D.

GALL BLADDER (NORMAL AND PATHOLOGICAL)

A New Combined Technic for Radiological Exploration of the Gall Bladder. M. Roses Artau. Am. Jour. Surg., March, 1930, VIII, 661.

The author combined the non-surgical biliary drainage with cholecystography and with the barium meal for the gastro-intestinal tract, and in this way he obtained information on the following points: (1) permeability of the common duct and a functional test; (2) cytological characteristics of the bile; (3) bacteriology; (4) permeability of the cystic duct; (5) morphology of the gall bladder, anatomical relations, and adhesions; (6) presence or absence of gallstones.

H. P. Doub, M.D.

Pharmacodynamic Effects upon the Gall Bladder. Alexander L. Bassin and Lester R. Whitaker. New Eng. Jour. Med., Feb. 13, 1930, CCII, 311.

The study of the effects of drugs upon motor activity of the gall bladder has been made possible by the development of cholecystography. In a long series of experiments

upon animals, profusely illustrated by serial roentgenograms, it was found that—

(1) Smooth muscle stimulants, barium chloride, pituitrin, and lead acetate produced definite but slight contraction of the viscus.

(2) Olive oil emulsion and egg yolk intravenously produced expulsion of the contents of the gall bladder, more pronounced than with any other substance.

(3) Rapid and vigorous but momentary expulsion of the contents of the vesicle was produced by "cholecystokinin."

(4) Ergotamine produced slight emptying of the gall bladder in some of the experiments. Physostigmine not only failed to produce emptying, but checked this when it had been started. Atropine ordinarily inhibited emptying.

(5) Calomel and magnesium sulphate administered by stomach tube had no effect, and magnesium sulphate intravenously produced only slight activity.

(6) Fats, in emulsion, either by mouth or intravenously, appeared to be the most constant and effective means of evacuating the gall bladder. This could be produced while the animals were under barbital and occasionally while under light ether anesthesia.

W. W. WATKINS, M.D.

Cholecystography. John F. McCullough. Penn. Med. Jour., March, 1930, XXXIII, 378.

Because of the wide differences in technic employed by various workers, there are bound to follow variations in results. Time alone will bring about the standardization which is desirable. Cholecystography has placed the diagnosis of gallstones on a very accurate basis, and when properly employed as a part of the clinical evidence, it constitutes one of the most valuable diagnostic procedures introduced in recent years. The pathologic manifestations generally agreed upon are: (1) demonstration of stones by the negative densities; (2) absence of the gall-bladder shadow, when the technic is accurate and carefully checked, has a definite significance, denoting abnormality somewhere in the bile tract; (3) deformities in outline; (4) variations in density, such as faintness, furnish the principal sources of error in the examination.

W. W. WATKINS, M.D.

The Clinical Value of Cholecystography. R. T. Wilson. South. Med. Jour., April, 1930, XXIII, 345.

In a series of 2,112 cholecystographies, 1,132 were classified as non-calculous cholecystitis, with 106 having associated calculus formation, being 58.6 per cent of the cases examined. In 139 out of 163 patients who had cholecystectomy, 85.3 per cent gave positive roentgen-ray evidence of gall-bladder disease. The oral administration is the method of choice. It has the advantage of ease and simplicity of administration, practically no contra-indications, and no systemic reactions. Irregularity in the cholecystogram has significance. The recognition of calculi is possible with a high degree of accuracy. In the patients in whom calculi were found at operation, 94.1 per cent had been detected by the X-ray examination.

W. W. WATKINS, M.D.

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

The Etiology of Diverticulitis. J. P. Lockhart-Mummery. The Lancet, Feb. 1, 1930, CCXVIII, No. 5553, p. 231.

This article is a most interesting contribution to our present knowledge of diverticulitis, and the author presents some very reasonable conclusions regarding the etiology and development of diverticulitis. He emphasizes the fact that multiple diverticula occur practically only after middle age and believes that the type causing diverticulitis is definitely not congenital in etiology. His reasons for believing this are, namely, the age of occurrence, and the fact that since cases have been followed with roentgen examinations over long periods it has been seen that diverticula

often develop in areas of the colon, which were previously of normal appearance. The author discusses the relation of diverticula to inflammation, and describes the earliest stage he has noted, that of large numbers of millet-seed projections on the outside of the colon, arranged in rows along the longitudinal muscle bands, at points where the lymphatic and blood vessels perforate the muscular coat. He feels that the diverticula start as pulsion herniations of the mucous membrane at the blood vessel foramina. He also notes that the condition is practically never present in thin persons.

Secondary inflammatory changes in diverticulous colons may occur at an early stage and produce fibrosis, or they may not occur until late in the development of the diverticula, or they may never manifest themselves.

M. J. GEYMAN, M.D.

The X-ray Study of the Large Intestines. George C. McElfatrick. Delaware St. Med. Jour., February, 1930, II, 26.

This paper and demonstration was intended to show how certain diseases of the large intestines are often confused with diseases of the stomach. Many symptoms ordinarily associated with ulcer and carcinoma of the pylorus and ulcer of the duodenum may occur, also from intestinal involvement, such as pain two or three hours after meals (relieved for a short time by taking light food), loss of weight, fatigue, gas and indigestion, gas and vomiting, heart pains, and constipation. A number of films were shown illustrating intestinal lesions which caused stomach symptoms.

W. W. WATKINS, M.D.

Some Cases of Congenital Anomalies of the Intestines. Dino Tartagli. La Radiologia Medica, March, 1930, XVII, 251.

This is a report on nine cases observed by the author, who compares the different embryological and anatomical analogies existing among them, to the characteristics revealed by radiological examination. These seem to have a common origin, although they show a totally different evolutive impulse. Some ectopies of the third portion of the duodenum are compared and reviewed by the author, who concludes by referring to discrepancies existing between clinical symptomatology and radiological verification.

L. MARINELLI.

Duodenal Hunger Contractions. Editorial (Current Comment). Jour. Am. Med. Assn., March 15, 1930, XCIV, 797.

This editorial comments on the researches of Carlson in Chicago and of Cannon in Boston and their assistance in formulating the now widely accepted dictum that hunger is due to pronounced motor activity of the stomach. Recently, Quigley and Solomon of the University of Chicago have observed "vigorous duodenal contractions during a period of complete gastric rest." Hunger sensations were reported at the same time. The conception of hunger sensations must, therefore, be enlarged to include the effects of duodenal contractions as well as the more familiar—and probably far more common and characteristic—changes in gastric motility.

C. G. SUTHERLAND, M.D.

The Roentgen Findings in Gastritis. Gustav Velde. Röntgenpraxis, April 1, 1930, II, 289.

The hope that roentgen examination would be able to make a definite diagnosis of gastritis in every case has not been fulfilled. A widening of the gastric rugæ alone is not enough for this diagnosis. Their width depends also on the tonus and the state of contraction of the muscularis mucosæ, as Gutzeit has shown. Definite gastritis, shown by gastroscopy, could not always be demonstrated by roentgenological examination. A negative X-ray examination does not exclude a gastritis. A definite diagnosis can be made when the rugæ are very markedly widened, and especially if the mucous membrane appears

granulated. A narrowing of the rugæ should not be interpreted as atrophic gastritis. The possibilities of error in the roentgen diagnosis of gastritis are great, and one should not read too much into the roentgenological picture of the gastric mucous membrane.

H. W. HEFKE, M.D.

Papilloma of the Duodenum. Milton R. Bookman. Ann. Surg., April, 1930, XCI, 626.

The author reports a case of papillary adenoma of the duodenum in a woman 39 years of age. The main findings in this case and others reviewed by the author were, blood appearing in the stools and well mixed with food residue, but without definite concomitant clinical signs of ulcer. Occasionally some degree of jaundice is associated with this condition. Such adenomata spring from the mucous membrane about the papilla of Vater.

Balfour and Henderson recently gathered the records of 131 benign growths of the duodenum. Golden has presented a collective review of 19 cases of papillomata of the duodenum, which included two of his own cases.

No roentgen-ray studies were made in the case outlined by the author. He states, however, that the roentgen rays give a fairly definite picture when it is obtainable, and he concludes that, in the face of active and massive bleeding, a well administered barium meal is less dangerous than the rather blind exploration of the abdomen in the hope of finding a source of the bleeding.

F. B. MANDEVILLE, M.D.

The Relationship of Duodenal Diverticula to Diseases of the Liver and the Bile Ducts. W. Stepp and K. Gutzeit. Med. Klin., April 4, 1930, p. 495.

Although many duodenal diverticula are symptomless and of no clinical importance, some, especially if large, may cause definite symptoms. Two cases are described in which fairly large diverticula were found roentgenologically. In both of these, pressure of the diverticulum led to obstruction of the bile ducts, icterus, and liver damage. The correctness of the diagnosis was corroborated by surgery in one case, and by autopsy in the other. The roentgen examination makes it possible to decide whether dietetic treatment or operation is indicated. Even after exact localization of the diverticulum by roentgenologic examination it is often difficult for the surgeon to find it. The duodenum occasionally requires opening, especially when the diverticulum is situated posteriorly. By resecting the diverticulum it is often possible to make the patient symptom-free and to prevent further damage to the bile ducts and the liver.

H. W. HEFKE, M.D.

Roentgen Diagnosis in Intestinal Obstruction. Sch. Samuelson. Röntgenpraxis, April 1, 1930, II, 297.

The X-ray examination of the abdomen without contrast media is not used often enough in cases of clinically suspected intestinal obstruction. It gives early evidence of the presence of obstruction and often, also, its seat. Gas bubbles and fluid levels in the small bowel are absolutely diagnostic and are found as early as two hours after the onset. Only rarely is it necessary to exclude a lesion in the colon by a barium enema. Examination without contrast media should be made with the patient standing, or lying on one side, preferably the former. The author describes seven cases and emphasizes the early roentgen examination in all cases of clinically suspected intestinal obstruction. The X-ray findings are much more reliable than any other clinical examination.

H. W. HEFKE, M.D.

Non-rotation of the Colon. Lon W. Grove. Ann. Surg., April, 1930, XCI, 615.

A case of non-rotation of the entire colon in a male 27 years of age is presented. Left-sided abdominal pain, with peculiar attacks of diarrhea following meals, were the main symptoms. Fluoroscopic and radiographic

studies demonstrated the cecum, the ascending and transverse portions of the colon to be joined together by adhesions and to be to the left of the median line.

At operation, X-ray findings were confirmed, and the portions of the colon mentioned above were found adherent to the duodenum and part of the jejunum, by a thin membrane. A colopexy was done according to the Coffey technic. A barium enema one and one-half years after operation showed the colon to be in normal position.

F. B. MANDEVILLE, M.D.

Fundamentals in Roentgenology of the Colon. James T. Case. Am. Jour. Surg., April, 1930, VIII, 844.

In this communication the author takes up the fundamentals describing the roentgen anatomy of the colon, including the mobility of various segments. Various formulas for opaque meals and enemas are given. The technic of injection of the enema, together with the apparatus necessary, is fully described.

This article is well adapted for beginners in roentgenology, going into the fundamentals in considerable detail.

HOWARD P. DOUB, M.D.

Diverticulitis of the Colon. Fred W. Rankin and Philip W. Brown. Surg., Gynec. and Obst., May, 1930, L, 836.

The history, etiology, pathology, and classification are discussed in this article. Under the symptoms, constipation was present in 60 per cent, diarrhea alone in 11 per cent, and tumefaction in 31 per cent. The diagnosis is chiefly roentgenological by a barium enema observed under the fluoroscope. Diverticula manifest themselves as rounded knob-like projections from the lumen of the colon, and show considerable variation in size. Sigmoid segment is the favored site, with diverticula becoming less numerous as the examination proceeds proximally. The roentgenological evidence of diverticulitis is that of spasm and hypermotility.

Differential points of diagnosis.—In diverticulitis concentric contours of the segment, maintenance of mobility, and a rather long segment of the colon are noted, while in carcinoma contours are sharply irregular, immobility is present, and there is a much shorter segment involved. Medical and surgical treatment are discussed and the following summary and conclusions are given:

1. Diverticulosis is quite prevalent, apparently occurring in about 5 per cent of persons who have symptoms referable to the large bowel, but probably actually occurring in about 1 per cent of all persons.

2. Diverticulitis probably occurs in about 17 per cent of cases of diverticulosis and in most instances is chronic in its course and subject to exacerbations.

3. The etiology of diverticula is obscure, but they are probably the result of several factors, among them inherent muscular weakness in the wall of the bowel and environmental conditions, obesity, and constipation.

4. Diverticulitis probably is the result of improper emptying of the bottle-shaped sacculations, with subsequent inflammatory reaction, necrosis, and occasional perforation.

5. The relationship of diverticulitis to carcinoma probably is incidental rather than actual.

6. In 227 cases reviewed in this paper, as treated at the Mayo Clinic, a malignant condition was found associated in four only.

7. Diverticulitis occurs almost entirely in persons of middle age who are inclined to be corpulent and who lead sedentary lives. Diverticulitis usually runs a chronic course with several exacerbations and yields satisfactorily to dietary and medical treatment.

8. The outstanding symptom of diverticulitis is pain, usually situated in the lower left portion of the abdomen, and is frequently associated with constipation. Change in bowel habit is a confusing factor.

9. Bleeding is not commonly found among the symptoms of uncomplicated diverticulitis or diverticulosis. When it does occur, an associated malignant condition is always suspected, but frequently not found.

10. Tumefaction associated with diverticu-

litis is common and usually is the result of inflammatory reactions, with or without formation of the abscess. In itself, it does not indicate associated malignancy.

11. The medical treatment of acute diverticulitis consists of a "watchful waiting" while the patient is at rest in bed and is given irrigation of the affected segment of bowel with warm sodium chloride solution and other sedative solutions. As the process subsides, anti-constipation diet and the use of small doses of mineral oil, orally, are given. A dietary regimen is highly essential and probably often prevents complications.

12. In a definite percentage of cases, diverticulitis tends to become complicated. The most common complications are abscess, fistula, and perforation.

13. The treatment of the complications of diverticulitis is usually surgical, particularly of the internal fistulous formation in which a viscus, such as the bladder, is penetrated by the inflammatory process.

14. Primary resection in the face of complications and diffuse inflammation is accompanied by a relatively high mortality rate. The operation of choice is a graded procedure, consisting of drainage and subsequent resection and anastomosis.

15. Often prolonged drainage by colostomy permits complete recession of tumefactions and disappearance of clinical symptoms, rendering unnecessary further intervention.

D. S. CHILDS, M.D.

GENITO-URINARY TRACT (DIAGNOSIS)

Cystography in Infancy and Childhood. Meredith F. Campbell. Am. Jour. Dis. Child., February, 1930, XXXIX, 386.

Age is no contra-indication to cystography—an infant of six days was included in this series of 150 cystographic examinations of children. Acute urinary infection of less than four weeks' duration is the main contra-indication. Among the indications are: chronic pyuria, enuresis, chronic urinary difficulty, frequency, dysuria, vesical pain, suprapubic mass, hematuria (not due to hemorrhagic nephritis). All the unusual pathologic conditions demonstrated in the adult may be noted in the child. Intra- and extra-vesical neoplasms are, of course, rare.

A 5 per cent solution of sodium iodide is injected with a soft rubber catheter after the patient has been catheterized and an enema administered. The injection is stopped when discomfort is noted. The average amount at two years is 30 c.c., at six years, 70 c.c., and at ten years, 100 cubic centimeters. The target of the tube is centered over the pubis; flash exposures are made without a Bucky. The Trendelenburg position is not used as reflux is to be avoided.

Vesical hypotonia was uniformly observed in choreic children. All showed abnormally large cystograms. A cystogram showing lateral displacement of the bladder, the result of tuberculosis of the seminal vesicle, was included. This demonstrated the characteristic finding in extra-vesical pressure. Advanced inflammatory disease of the bladder walls was found to be more common than tuberculous processes.

Ureteral reflux was noted on one or both sides, depending on the degree of inflammatory involvement of the ureterovesical valves. The author disagrees with Kretschmer and does not believe that reflux may occur in the normal bladder. Of the 150 cases, 12 per cent showed reflux, unilateral in eight and bilateral in ten cases.

In diverticulosis, Hinman's method—the emptying of sodium iodide and refilling the bladder with air for further roentgenograms—was found to be very satisfactory.

F. B. MANDEVILLE, M.D.

Ureteral Kinks: How They Occur at the Order "Take a Deep Breath and Hold It." Gershom J. Thompson and Hermon C. Bumpus, Jr. Jour. Am. Med. Assn., March 15, 1930, XCIV, 771.

In reviewing their old pyelograms, the authors were surprised to find how frequently ureteral kinks were apparent in one and absent

in the other of two films made on one patient. It was found that a ureterogram made while the patient was holding the breath (deep inspiration) would show a ureteral kink, while one made after the patient had relaxed (deep expiration) would show a straight ureter. These cases are reported in detail.

The authors' conclusions are that kinks of the ureter may be present without symptoms; their correction by surgical measures should be delayed until urinary stasis is demonstrated.

C. G. SUTHERLAND, M.D.

Excretion Urography: A Preliminary Note on a New Method of Radiological Demonstration of the Urinary Tract. Kenneth Heritage and R. Ogier Ward. Brit. Med. Jour., April 19, 1930, No. 3615, p. 734.

Since Graham's epoch-making work on cholecystography a number of workers have been active in the search for a suitable non-toxic, yet selective excretory substance to visualize the urinary tract. Rosenow conceived the idea of combining intravenous administration of sodium iodide (the iodide equivalent of 38 grams of iodine) and urea, with subsequent radiography of the urinary tract. Recently, the work of Swick, Binz, and Raeth has resulted in the production of uroselectan.

This preparation has proved satisfactory. It is harmless even in large quantities (3 grams per kilo of body weight is tolerated by the guinea-pig); it is soluble up to 50 per cent, contains 42 per cent iodine in organic combination, and is excreted unchanged from the kidneys in sufficient concentration to give good radiographic shadows. In fact, it can be almost completely (95 per cent) recovered from the urine.

Uroselectan is given intravenously on the X-ray table, 40 grams dissolved in 100 c.c of water for an adult male. An iodide idiosyncrasy must be sought beforehand. The first roentgenogram is taken 10 minutes after injection. Further roentgenograms are taken one-half hour, one hour, and two hours after injection. After clinical observations on a series of over two hundred patients, the authors come to the following conclusions:

1. By this method of urography a roentgenogram is obtained of the whole urinary tract without instrumentation, provided both kidneys retain in some degree their excretory function.
2. The method offers a differential test of renal function.
3. The procedure is harmless.
4. The results are easily obtained, of good quality, and in most cases, leave no doubt as to the condition present.
5. There are certain contra-indications to the use of this method.
6. The method promises to be of great value in elucidating the pathology of surgical disease of the kidney.
7. Cogent indications are: impassable obstruction of the urethra or of the ureters, severe hemorrhage, multiple urinary fistulæ, "thimble bladder" in the case of small children, or in cases of implantation of the ureters into the bowel. In prostatic hypertrophy, with intravesical projection rendering ureteric catheterization both difficult and inadvisable, the intravenous method will also find a place.
8. The exclusion of latent uremia by blood urea examination is an important preliminary.

H. W. DUNDAS MACKENZIE, M.D.

Recent Advances in the Renal Surgery of Childhood. R. I. Harris. Can. Med. Assn. Jour., March, 1930, XXII, 358.

The recent introduction of special cystoscopes of small size has permitted, for the first time, investigation of the genito-urinary tract of children with the same completeness that for many years has been possible in adults.

The commonest lesion of the urinary tract in children is that termed "pyelitis." In a few cases of the chronic type of this condition the author found no signs of obstruction or dilatation of the urethra, bladder, or ureter. The kidney pelves were normal and pyuria was frequently unilateral. Examination of a kid-

ney removed at operation showed the condition to be a pyelonephritis, and not a pyelitis.

A great many cases of so-called pyelitis were found to be cases of urinary infection behind a mechanical obstruction. These obstructions were found in the urethra and ureters. The urethral obstruction was found only in males and was due, in most cases, to congenital valves in the prostatic urethra. Occasional stricture of the male urethra was found. Ureteral obstruction was found in both male and female.

The paper is well illustrated with pyelograms.

L. J. CARTER, M.D.

GYNECOLOGY AND OBSTETRICS

On Light and Heat Therapy in Gynecology. Wilhelm Flaskamp. Strahlentherapie, 1929, XXXII, 672.

This is a well illustrated article describing the equipment and methods used in the Erlangen Clinic for light and heat treatments. A considerable number of gynecological diseases lend themselves successfully to physical therapy. A very careful procedure has been worked out in each case, requiring patience from both physician and patient. The article is recommended for study in the original.

E. A. POHLE, M.D., PH.D.

The Present Status of Gynecological Radiotherapy. Michael Bolaffio. Strahlentherapie, 1930, XXXVI, 201.

The author gives a brief résumé of his report made before the last Annual Meeting of the Italian Society of Gynecology and Obstetrics. The article does not lend itself to abstraction but it should be looked up, however, in the original, for two reasons: in the first place, one gains a rather complete impression of the status of radiotherapy in Italian gynecological clinics, and the synopsis of the discussion following the reading of the paper brings out very clearly the conception and difference in opinion of the various schools.

ERNST A. POHLE, M.D., PH.D.

HEART AND VASCULAR SYSTEM (DIAGNOSIS)

Vertebral Erosion Due to Aneurysm. Antonio D'Istria. La Radiologia Medica, January, 1930, XVII, 1.

The author states the difficulties the radiologist encounters in the diagnosis of aneurysm of the descending aorta. In order to establish the general features of vertebral erosion due to aneurysm, the author analyzes the results obtained in five cases in which the diagnosis was confirmed at autopsy. They may be summarized as follows: multivertebral lesions of generally round contour, more marked at the center of each vertebra, with a tendency to spare vertebral discs; normal structure of the vertebral part not affected. The author mentions the diagnostic details which differentiate other osteo-destructive diseases, and concludes that the mechanical theories are the most apt to explain the effects of aneurysm.

L. MARINELLI.

HODGKIN'S DISEASE (DIAGNOSIS)

Hodgkin's Disease of the Lungs. A. Held. Fortschr. a. d. Geb. d. Röntgenstr., February, 1930, XLI, 191.

Malignant granuloma (lymphogranulomatosis or Hodgkin's disease) may cause a great variety of pictures within the thoracic cage, other than swelling of the lymph nodes. Four types of intrathoracic pathology due to this disease are described: (*a*) simple mediastinal lymphatic tumors; (*b*) mediastinal tumors with direct extension into pulmonary tissue; (*c*) independent pulmonary processes associated with mediastinal tumors; (*d*) disseminated pulmonary form. A number of case reports illustrate the different types, some of which closely resemble tuberculosis. The association of lymphogranulomatosis with tuberculosis, however, is rare. Diagnostic irradiation may help in differentiating between the two types of infection. Occasionally cases

have been observed with lymphogranulomatosis upon which previously a diagnosis of pulmonary tuberculosis was made because of pulmonary symptoms, until the roentgenologic examination revealed the nature of the pathology. A differential diagnosis is not usually complicated by results of bronchostenosis and pulmonary atelectasis, with or without secondary infection. The response to radiation treatment is usually very prompt. A histologic diagnosis cannot be made from irradiated lymphatic tumors or tumors which undergo frequently occurring regressive stages.

H. A. JARRE, M.D.

Concerning Lymphogranulomatosis (Hodgkin's) of Bones. H. Friedrich. Fortschr. a. d. Geb. d. Röntgenstr., February, 1930, XLI, 206.

This is the report of a case of Hodgkin's disease of the mandible in a young adult. The bone showed considerable enlargement with a coarse irregular honey-combed structure. Enlarged cervical lymph nodes were found associated with the bone tumor. The diagnosis was made, histologically, on one of these lymph nodes which was removed. A small piece of bone removed for histologic examination revealed signs of marked new bone formation, associated with marked bone resorption. The pathologist thought it best to correlate this picture with a diagnosis of osteitis fibrosa, but remarked that a correct diagnosis may not be possible. This bone tumor responded very readily to radiation treatment, but the patient succumbed to the disease within two and one-half years. The author points out that a differential diagnosis from osteitis deformans could not be made roentgenologically, but only on histologic examination of one of the enlarged lymph glands. Very few cases of Hodgkin's disease of the bones are reported in the literature, and a communication of further cases is requested.

H. A. JARRE, M.D.

HODGKIN'S DISEASE (THERAPY)

Concerning the Prognosis in Hodgkin's Disease. B. Kuhlmann. Strahlentherapie, 1930, XXXV, 296.

It is generally accepted that the average expectancy of life after the onset of the symptoms is about two and one-half years. However, instances are on record in which the patient lived up to thirteen years and responded well to radiation therapy. The author relates the history of a patient sixteen years of age who came under observation in April, 1923. He complained of shortness of breath at that time, and there were tumors of hen's egg size in both parotid regions. Smaller glandular enlargements could be palpated in both supraclavicular regions and in the left groin. The roentgenogram of the chest showed enlargement of both hili. Biopsy verified the clinical diagnosis. Small doses of roentgen rays (one-third E.D.) at 190 K.V., filtered through 0.5 Cu plus 1.0 Al, were given at about six week intervals. At the same time, the patient received ultra-violet therapy over the body. At present, that is, over six years after the onset of the disease, the patient is well and without clinical manifestations of the disease.

E. A. POHLE, M.D., PH.D.

The Treatment of Lymphogranulomatosis. J. Jacobs. Strahlentherapie, 1930, XXXV, 533.

X-ray therapy of Hodgkin's disease is recommended to be applied only to the diseased glands. A conservative procedure is indicated because large doses may lead to intoxication. It is also to be considered that a chronic disease of this nature will require repeated treatments and large doses are not practical because of the lessened skin toleration. The best procedure is undoubtedly to find out the minimum dose required in each case for response. As a rule 30 to 50 per cent of the erythema dose with heavily filtered radiation should suffice. The author also used, with advantage, the intravenous injection of dextrocid which is an iodin-cer compound coupled to a

30 to 50 per cent dextrose solution. A few cases are reported, illustrating that the tumors apparently respond better under this combined treatment.

E. A. POHLE, M.D., PH.D.

LIGHT THERAPY

The Finsen Treatment of Small-pox. C. H. Würtzen. Strahlentherapie, 1930, XXXVI, 311.

On the Finsen Treatment of Small-pox. Leopold Freund. Strahlentherapie, 1930, XXXVI, 320.

Würtzen discusses the treatment of small-pox as proposed by Finsen, who excluded all chemically active rays from the sick-room. This can be done by covering the windows with red cloth or by using a red glass. The results were good in certain clinics and disappointing in others.

In the discussion, Freund emphasizes the statement that it is not possible to filter out all chemically active rays, and he suggests, therefore, the designation of this treatment method as the "red room treatment." Upon his recommendation, an ointment containing 6.5 per cent rapid filter red was tried out on small-pox lesions, not covered by clothing. This was, however, without success.

ERNST A. POHLE, M.D., PH.D.

MEASUREMENT OF RADIATION

Concerning Roentgen Dosimetry in Dermatology. Franz Thedering. Strahlentherapie, 1930, XXXVI, 127.

Concerning Roentgen Dosimetry in Dermatology. G. Schulte. Strahlentherapie, 1930, XXXVI, 132.

Thedering recommends extremely small doses in the treatment of skin diseases. He administers from 0.1 x to 0.3 x, 8 inch spark gap, 0.5 mm. to 3.0 mm. Al. In his experience, the results have been most favorable and there is no danger of late reactions.

Schulte does not agree with this point of view and urges the retention of the fractional method, applying about one-third of a skin unit every ten days. He has never seen any late reactions even after the application of three full skin units during a period of fifteen months. An examination of the skin capillaries before repeating the treatment seems, however, advisable in the light of our present knowledge.

ERNST A. POHLE, M.D., PH.D.

Dosimetry in Radiological Diagnostics. Arduino Ratti. Atti del Raduno Radiologi Alta Italia, October, 1928, VI, 233.

This is a comparative analysis of the radiation emitted by three diagnostic tubes of different make, having the same rating and used under identical conditions. Important discrepancies in both quality and quantity of the output were noticed, and the author points out that, while they have practically no effect on either the radiographic or radioscopic image, they must be considered, especially in radioscopy, in relation to the safe limit of radiation that the skin can absorb. The routine use of aluminum filters from 0.5 to 1 mm. thickness is recommended.

L. MARINELLI.

MEDICAL PRACTICE

Radiation Service in the Modern Hospital. Albert Soiland and Orville N. Meland. Jour. Am. Med. Assn., Jan. 25, 1930, XCIV, 239.

In modern hospitals there has been an endeavor to increase radiologic efficiency. These authors discuss the accomplishments of irradiation in the various ills to which man is disposed. A separate department with its own equipment is essential if a great deal of treatment work is to be done. It is better to have good irradiation from an X-ray installation than to have inadequate radium or radium

therapy in the hands of the inexperienced. Granting the radiologist has the training and experience, he should keep his associates informed as to the possibilities in his particular line.

C. G. SUTHERLAND, M.B. (Tor.)

OFFSPRING, EFFECT ON

Post-conception Pelvic Irradiation of the Albino Rat (Mus Norvegicus): Its Effect upon the Offspring. Douglas P. Murphy and Marguerite De Renyi. Surg., Gynec. and Obst., May, 1930, L, 861.

The irradiation was given with equipment of the mechanically rectifying type, energizing a broad-focus Coolidge tube. The roentgen machine was calibrated with a Wulf ionometer, the latter in turn calibrated in Germany with the proposed international r. The operating factors were as follows: 127 K.V. (peak); 5 ma.; 30 cm. skin target distance, and 6 mm. of aluminum. One hundred and eighty milliampere-minutes (ma.-min.) of exposure gave 800 r of intensity. With this technic, 120 animals were subjected to from 1 to 6 exposures, varying in strength from 45 to 360 ma.-min. (200 to 1,600 r).

Gestation in the rat consumes from 22 to 23 days. Of the 120 treated animals, 34 cast litters within less than 22 days of their last roentgen exposure, *i.e.*, the embryos in these cases had received at least one roentgen exposure. The litters of these 34 animals varied in size from 1 to 11, the most common being 2, with an average size of 3.6 young. In a group of 35 control litters the most common size was 7 young. Grossly defective young were cast by 5 of the 34 irradiated animals. The number of these young appeared to be in direct proportion to the degree of the irradiation. These litters comprised a total of 13 offspring, of which 2 were known to be alive at birth but died within a few hours. The remaining 11 were either stillborn, or were killed by their parents, or died natural deaths before being observed. Of the whole group of 13 young, 6 exhibited developmental defects of the extremities.

Of the 5 animals casting litters containing defective young, 4 gave birth to a total of 10 offspring, all of which were, at least externally, well formed, except for a foot deformity exhibited by 5 of them. The foot abnormality exhibited by these 5 young was characterized by lack of the normal depth of the digital grooves. In 4 of the 5 animals only the hind feet were affected, while the fifth one exhibited the defect in all four feet. Where the digital grooves were absent or distorted, the entire foot was deformed so as to appear clubbed. In a number of instances the end of the extremity was perfectly smooth, similar in appearance to an amputation stump of long standing. In those instances in which only the hind feet were affected, the fore feet appeared to be perfectly normal in every respect.

The fifth litter consisted of only one young. This animal appeared to be perfectly healthy and lived until the end of the experiment. Its fore feet, however, had only three well developed toes each, with the normal site of the missing toe marked by a rudimentary bud which suggested an arrest of development.

It is believed that the abnormalities which have been described are the result of the embryonic irradiation. The clinical findings suggest this as does also the earlier experimental evidence advanced by other workers. In the case of the present experiment, the defects varied (at least in frequency) with the degree of the embryonic exposure. The same defect was observed several times in the same litter and in more than one litter.

It is significant that the deformities observed among the young of animals irradiated when pregnant have not been duplicated in a series of 125,000 non-irradiated control animals.

D. S. CHILDS, M.D.

PROTECTION

Is the Radiologist a Public Danger? British Medical Journal Correspondent (France). Brit. Med. Jour., Nov. 30, 1929, No. 3,595, p. 1026.

In France a newspaper campaign was

started in the lay press against the "terrible danger" of X-rays to the public and especially to those persons who live in the immediate neighborhood of a radiologist. The argument was purely theoretical, and no proof whatever was offered. As Dr. Maingot ably replied, not only do we prevent the rays escaping from our rooms, but we prevent them escaping into our rooms, and the radiologist works in an X-ray proof atmosphere. This information, spread to the public through the press, has prevented a panic which might have proved most prejudicial to the specialist.

W. D. MACKENZIE, M.D.

Better Protection in Vertical Fluoroscopy. J. Belot. Am. Jour. Surg., April, 1930, VIII, 859.

The author states that the three dangers present in vertical fluoroscopy are: first, danger of electrocution; second, danger from direct irradiation, and third, danger from absorption of secondary rays.

He describes a fluoroscope which he has had constructed and which he believes gives complete protection to the radiologist in these regards. In this, the tube and all high tension wires are situated in another room and the field of rays is thoroughly shielded.

HOWARD P. DOUB, M.D.

RADIATION SICKNESS

Activated Ergosterol in Radiation Sickness. Lester A. Smith. Am. Jour. Roentgenol. and Rad. Ther., October, 1929, XXII, 317.

Fifty-five cases undergoing intensive roentgen or radium irradiation were simultaneously given activated ergosterol in four to eight minim doses two or three times daily. All but ten of these patients were completely relieved of nausea. Seventeen of them had had previous series of treatments without ergosterol, under such conditions showing radiation sickness. In many cases the patients described a sensation of unusual well-being and a great improvement in appetite. The effect is believed to be brought about by altering the calcium-phosphorus metabolism.

J. E. HABBE, M.D.

RADIUM

A Case of Granuloma Annulare Cured with Radium. C. J. Broeman. Jour. Med., February, 1930, X, 597.

The text-book treatment of this condition, with the exception of the X-ray, is a more or less destructive one by chemicals, leaving more or less scarring. X-ray has been mentioned by several writers as of benefit. In the case cited, 25 mg. of radium in a 0.5 mm. silver capsule and 1 mm. brass, at a distance of one-eighth inch was applied for three hours; eleven days later it was repeated for two hours, using 50 mg.; twenty-one days later, 50 mg. for two hours. Five months later the lesion was entirely cured, and the skin of the hand was perfectly normal.

W. W. WATKINS, M.D.

Modification of the Technic of External Radium Applicators. Mario Maino. La Radiologia Medica, February, 1930, XVII, 109.

The author considers the present technic of external radium application either unsatisfactory or too complicated. He advises the adoption of paraffin reinforced by a soft and homogeneous layer of absorbent cotton, having the same dimensions as the applicator. This method is simple, avoids fragility, and retains solidity and lightness. It is appropriate for long treatment and it was found not to affect, in any way, the uniformity of the radiating beam.

L. MARINELLI.

The Use of Radium in the Treatment of Uterine Hemorrhage. Gerry H. Holden. Jour. Florida Med. Assn., February, 1930, XVI, 355.

Uterine hemorrhage is not a disease but a symptom of many disorders, of which the

following are discussed as being amenable to radiation: Cancers of the uterus, myomatous tumors of the uterus, functional or idiopathic uterine hemorrhage. The bleeding from cancer of the uterus is controlled by the natural regression which takes place following radium treatment. In fibroid tumor the degree of success in stopping hemorrhage with radium will depend upon the care of selection of cases; only about 40 per cent should be treated with radium. Cases of menorrhagia and metrorrhagia without tumor formation can usually be controlled by radium radiation—whether or not the treatment is best for the individual case can be determined only after careful analysis. As a general rule, radium should be used only at or near the menopause, and where there is no pelvic inflammatory lesion present.

W. W. Watkins, M.D.

The Effect of Radon on the Distribution of Phosphorus in Normal Dogs. Nina Kotschneff and Anna Arapoff. Strahlentherapie, 1930, XXXVI, 360.

The distribution of phosphorus in normal dogs was studied with the method of Dr. E. S. London (angiostomy method). If from 10 to 30 mc. of radon were injected into the blood stream, stomach, intestines, or gall bladder of fasting dogs, there followed a drop of the inorganic phosphorus. The same observation was made during the digesting period. A study of the phosphorus content of the blood in various regions of the body showed that the drop was most pronounced in the blood of the kidney veins.

Ernst A. Pohle, M.D., Ph.D.

The Diagnosis and Treatment of Abnormal Uterine Bleeding. Archibald L. McDonald. Minnesota Med., March, 1930, XIII, 172.

After considering the bleeding due to pathologic conditions in early pregnancy, the author discusses bleeding due to local causes, under three heads. (1) Pre-climacteric hypertrophy of the endometrium, which he says should be treated by curettage. (2) Submucous or pedunculated fibroids associated with hyperemia; if curettage shows cancer not present, the author states that excision of the growth and hysterectomy is the proper procedure, and radium is not advised. (3) Cancer of the body should be treated by hysterectomy, and cancer of the cervix with radium.

(Abstractor's note: Radiologists will not agree that radium has no place in treating either Class 1 or 2 of this grouping, but insist that it has a very large place in both groups.)

W. W. Watkins, M.D.

The Rôle of Secondary Beta Rays in Gamma-ray Therapy. A. Piccard and E. Stahel. Strahlentherapie, 1930, XXXVI, 347.

A number of interesting experiments dealing with the ionization measurements of radium preparations under various conditions are discussed, and the following conclusions presented. In all treatments with gamma rays, it is entirely superfluous to use a so-called secondary filter; in other words, it is not necessary to surround filters of platinum, gold, or brass by aluminum or rubber, for instance, because the secondary radiation is not appreciably influenced by this method. It is possible when using radium preparations (gamma rays) at distances to decrease the amount of radiation in the upper layers of the skin. This can be done by using a magnetic field or by a proper localization and arrangement of filters.

Ernst A. Pohle, M.D., Ph.D.

Relative Value of Radium and X-ray Therapy in Malignant Disease. N. S. Finzi. Brit. Jour. Radiol., April, 1930, III, 161.

The author has been using radium for over twenty years and X-rays therapeutically for several years longer. With each increase in voltage and filtration improved results have been noted. Because of the further development possible with X-rays, it is believed that there will be advances made with X-ray therapy. While every case must be decided on its own merits as regards the use of X-ray or

radium or both, the following are the general conclusions of the writer:

In very radiosensitive and rapidly growing tumors, such as lymphosarcomas, X-ray therapy is always the treatment of choice.

With very small growths which tend to remain localized (for example, rodent ulcer, epithelioma of the larynx) radium is always preferable.

In radioresistant tumors, radium is the method of choice. By increasing the period of exposure from five to six weeks with daily applications, the results with either X-rays or radium are improved.

In growths of the mouth and upper air passages, X-rays alone or in combination with radium are preferred because of the greater homogeneity of the X-rays.

In tumors of the cervix, radium for the primary tumor and X-rays for the pelvic glands give the best results.

In rectal carcinoma, radium is advised.

In breast cases, radium needles give good results where such a method is suitable, but for mediastinal extension X-rays are chosen.

The skill of the radiologist varies as much as the skill of the surgeon, and skill is a large determining factor in the results obtained.

J. E. Habbe, M.D.

Concerning Radium Treatment of Malignant Struma. Fritz Dautwitz. Strahlentherapie, 1930, XXXVI, 32.

The introduction to this article offers a review of the international literature on malignancy of the thyroid, comparing the results obtained by surgery and radiation. The author has treated twenty-five cases of this type with radium (gamma rays). Surface applications containing from 40 mg. to 90 mg. of radium, at from 1 cm. to 3 cm. distance, using the cross-fire method, were employed, at an exposure per treatment of from 6 to 12 hours. This was repeated at certain intervals. The average dose for inoperable cases amounted to about 11,000 milligram-hours. In resistant malignancies, about 13,000 mg.-hrs. were used. The maximum dose given in any case in one series was somewhat over 18,000 milligram-hours. The statistical survey of the patients shows that of the fourteen inoperable ones, six died during the first year following the treatment, one each died during the second, third, and eleventh years. Fourteen years after treatment, one patient was still alive; no answer was obtained from three patients, and the cause of death of one patient could not be learned. Of the eleven patients suffering from recurrent malignant struma, three died during the first year following the treatment, one died four years later, one is alive after two years, three are alive after four years, and one each, six, eight, and twelve years following the treatment.

Ernst A. Pohle, M.D., Ph.D.

On the Theoretical Foundation of Internal Radium Therapy, Emanation Therapy, and Biologic Dosage. J. Markl. Strahlentherapie, 1930, XXXVI, 337.

The amount of emanation in the blood and in the gastric juice up to about two hours after drinking 100 c.c. of water containing 200,000 ME. (Mache units) was determined. It appeared that the individual variations were higher than those due to the influence of eating. A calculation shows that the amount of emanation found corresponds to about from 7,000 to 10,000 Alpha rays per c.c. of tissue. The possible biologic effect of such small energies is discussed.

Ernst A. Pohle, M.D., Ph.D.

RICKETS (THERAPY)

Sunlight Type S-1 Lamp (G. E.) Therapy in Human Rickets and Rachitic Spasmophilia. Henry J. Gerstenberger and G. Richard Russell. Jour. Am. Med. Assn., April 5, 1930, XCIV, 1049.

Three rachitic patients were exposed once a week in such a manner as to produce a definite erythema. In each patient a decided improvement in the blood calcium and inorganic phosphate level was recognizable after two

weeks. Normal figures were reached in from four to seven weeks. Roentgenographic study agreed with the above findings.

C. G. SUTHERLAND, M.D.

Treatment of Rickets with Irradiated Milk. Rudolf Hess. Strahlentherapie, 1929, XXXIV, 787.

Irradiated fresh milk is not a reliable agent in the treatment of rickets, according to the experience of the author. Irradiated powdered milk and irradiated ergosterol (Vigantol) compared favorably with the therapeutic effect of the radiation of the sun or of the quartz mercury vapor lamp.

E. A. POHLE, M.D., PH.D.

ROENTGEN THERAPY

Radiation Therapy of Bone Metastases in Carcinoma of the Breast. A. Beck. Strahlentherapie, 1930, XXXV, 513.

The author discusses the problem of bone metastases appearing after radical removal of carcinoma of the breast. To judge from the literature on the subject and from his own experience, X-ray therapy offers not only palliation in this type of case, but quite frequently leads to a temporary cure of the bone lesions. The histories of three cases, accompanied by roentgenograms, are briefly related, illustrating the good response of the bone metastases to X-ray deep therapy.

E. A. POHLE, M.D., PH.D.

Deep X-ray Therapy: Conclusion Derived from the Treatment of Five Hundred Cases. E. C. Thrash and W. Pope Baker. Jour. Med. Assn. Georgia, February, 1930, XIX, 58.

X-ray therapy is by no means confined to malignancies, but many other stubborn pathological conditions are amenable. Therapeutic work has been done at 200 K.V., 15 to 30 ma., distance of from 30 to 50 cm., copper and aluminum filtration, 200 to 600 milliampere-minutes. Dosage is classed as lethal, paralethal, and reactionary. Condemnation of X-ray therapy is believed to have been caused by over-treatment. The aim of the authors is not so much to remove the tumor growth in cancer, as to cause its replacement by fibrous tissue sufficient to stop its growth; arrest can often be brought about without even perceptibly diminishing the size of the tumor. Most breast cancers are primarily surgical, but in most cases X-ray treatment should be associated. Good results have followed treatment of cancers of the abdominal viscera, and success in this field is attributed to the fact that they are not over-treated. Among other conditions successfully treated are mentioned sycosis (100 per cent), chronic scaly eruptions of all kinds, epidermophytosis, chronic neuritis, simple bronchial asthma, and hay fever.

W. W. WATKINS, M.D.

Chloroma: Report of a Case with Recovery Following Roentgenotherapy, with a Review of the Literature. Alfred H. Washburn. Am. Jour. Dis. Child., February, 1930, XXXIX, 330.

A case of myelogenous chloroma in a boy aged twenty months, is presented. The diagnosis was established by complete blood, roentgen, and pathologic studies. A complete cure resulted, following roentgen therapy, which has lasted for two and one-half years. Roentgenograms before and after treatment are included.

The author recognizes a myelogenous and a lymphatic type of chloroma. His review of the literature from 1823 to June, 1929, revealed 162 cases of chloroma and 20 additional doubtful cases. Most of the recent cases have been of the myelogenous type, and there is evidence which indicates that chloroma is a form of myelogenous leukemia.

Treatment consisted in a relatively long course of small doses, lasting over a period of five months. The mediastinum and lower extremities were treated. The factors were: 12-inch distance, 9-inch spark gap, 0.25 mm. Cu and 1 mm. Al, 100 to 150 ma.-min. The

size of the fields was not included, but a detailed table of the general areas treated was given. Doses were said to represent 50 per cent of a skin tolerance dose.

F. B. MANDEVILLE, M.D.

On the Roentgen Late Ulcers. Béla Kelen. Strahlentherapie, 1930, XXXVI, 116.

The author discusses the literature on X-ray late reactions; he has not seen one single case of idiosyncrasy among 18,000 therapeutic and 34,000 diagnostic patients. The histological findings of two roentgen ulcers are given in detail. A statistical survey of his patients, grouped according to the treatment technic, indicates that all cases treated with unfiltered roentgen rays showed telangiectasis, and several developed ulcers; 2,950 patients were treated through 3.0 mm. Al. Only in those treated over a longer period were late reactions observed, while in 1,684 cases treated with heavily filtered deep therapy radiation, not a single case of telangiectasis or late reaction has been reported so far. The best prophylaxis for avoiding late reactions is proper filtration, the producing of only mild skin reactions, and the strict observance of sufficient intervals between treatments.

ERNST A. POHLE, M.D., PH.D.

Principles of Roentgenotherapy: III.—The Biological Effect of Roentgen Rays on Normal Tissue. Ernst A. Pohle. Wis. Med. Jour., March, 1930, XXIX, 149.

Biologic effect of X-rays is dependent on absorbed energy and not on wave length. There is no proof, as yet, that the Arndt-Schultz law applies to roentgen rays, that small doses stimulate, medium doses inhibit, and large doses destroy cells. There is no selective action of X-rays on cells, the variations in effects being due to varying susceptibility of various types of tissue. Wetterer's schematic scale of susceptibility, beginning with lymphatic tissue and ending with bone, is not entirely dependable. The action of the roentgen rays on the skin, mucous membranes, blood, bone marrow, spleen and lymph glands, sex glands, glands of external secretion, thymus, suprarenals, gastro-intestinal tract, nervous system, heart and lungs, bone muscle and connective tissue, is discussed in this article, which is No. 3 of a series on the same general subject.

W. W. WATKINS, M.D.

Unusual Resistance of the Ovary to Roentgen Rays. Gustaf Blass. Strahlentherapie, 1930, XXXVI, 370.

In a girl seventeen years of age an ovarian tumor was removed; the microscopic examination showed a fast-growing carcinoma. During the following six months, X-ray deep therapy was applied to the pelvis. A total of 1,800 r was effective in the ovaries. The last treatment had been given in August; in September, the menstruation still appeared and was perfectly normal. The author reports this case because of the most unusual resistance of the ovary to irradiation.

ERNST A. POHLE, M.D., PH.D.

Roentgen Therapy of Inflammations of Glandular Organs. Carl Fried. Strahlentherapie, 1930, XXXVI, 161.

In thirty-one cases of parotitis, five of which were chronic, the results were good in 42 per cent, satisfactory in 35.5 per cent, doubtful in 9.7 per cent, negative in 6.5 per cent, and unknown in two cases. Three patients suffering from strumitis responded well. In thirty cases of mastitis, 50 per cent responded favorably, 26.7 per cent were benefited; in 13.4 per cent the effect was doubtful, and in 6.6 per cent negative. One patient did not return. In seven cases of orchitis and seven cases of epididymitis, all responded well except in one single case, while one patient could not be observed further. In individuals suffering from prostatitis not enough experience has been accumulated to warrant any statistics. While in most inflammations of the glands, 160 r may be given, 100 r to 120 r, or even less, should be considered in treating

the testicle. For parotitis and mastitis, it seems advisable to increase the dose to 200 r.

ERNST A. POHLE, M.D., PH.D.

The Treatment of Erysipelas with X-ray. Richard W. Fowlkes. South. Med. and Surg., March, 1930, XCII, 163.

This method of treating erysipelas is not new, it having been reported by Magelhaes (1914), Schmidt (1917), Hesse (1918), Schrader (1921), Hiedenhain (1926), and several others. The most notable group were those reported by Platou and Rigler of the University of Minnesota in 1926. The author reports two cases in detail, typical of the seventeen cases treated by them. The conclusion is that the effect of X-rays on the infection is generally rapid, is painless and causes no local or systemic reaction, and complications are usually avoided.

W. W. WATKINS, M.D.

Contribution to the Roentgen Treatment of Chronic Inflammatory Diseases of the Eye. Felix Jendralski. Strahlentherapie, 1930, XXXVI, 327.

In inflammation of the cornea, X-ray therapy is of value in many cases; for tuberculous processes, always. Keratitis-parenchymatiosa, particularly severe cases, respond well. In scleritis, the inflammation usually subsides quickly following irradiation, without leading to complications, while some benefit may be obtained in choroiditis and in isolated tuberculous foci. The roentgen rays were filtered through 3.0 mm. Al and one-third to one-half Sabouraud-Noiré dose was given in one sitting. Even repeated treatments did not produce an erythema.

ERNST A. POHLE, M.D., PH.D.

The Rationale of Roentgen Therapy in Infections. Fred M. Hodges. South. Med. Jour., March, 1930, XXIII, 259.

After a fairly extensive experience in the treatment with the X-ray of localized infections, the author concludes that irradiation offers more than any or all other forms of treatment in early erysipelas in adults, in furunculosis, and in subacute or chronic parotitis, with or without sinuses. Just what causes the changes produced by radiation is not known. The most likely theory seems to be that some antibody product is released by destruction of the cells, especially the lymphocytes, which increases phagocytosis. In carbuncles the X-ray gives better results than does any other form of treatment, but more accurate dosage and finer judgment are required. Slow-healing sinuses, post-operative and otherwise, are usually definitely speeded up by this treatment. In cellulitis of the neck and face, irradiation is definitely helpful.

W. W. WATKINS, M.D.

Principles of Roentgenotherapy: IV.—The Systemic Effect of Roentgen Rays. The Roentgen Reaction in Pathologic Tissue. Ernst A. Pohle. Wis. Med. Jour., April, 1930, XXIX, 207.

This is the fourth of a series of articles on the principles of roentgenotherapy. It discusses the blood composition changes following X-ray exposure and the histologic changes in the tissues. Upon the knowledge of these changes we base our conclusions regarding the effects of radiation on disease processes.

W. W. WATKINS, M.D.

Five Years' Experience with Radiotherapy in Uterine Conditions. J. S. Wilson. Jour. Arkansas Med. Soc., April, 1930, XXVI, 215.

The author has treated approximately 120 cases of uterine conditions by radiotherapy since 1923, and reports on the first 100 of these. Of these, 26 were functional menorrhagia or metrorrhagia, and were treated by intra-uterine radium 1,200 to 2,400 mg.-hrs., with one hour of X-ray over each ovary. Radium was filtered through 0.5 mm. silver and 2 mm. brass covered with rubber; X-ray at 135 K.V., 10 inch distance, 0.5 mm. Cu and

0.5 mm. Al filter. Results were all satisfactory. Twelve cases of fibroids were given the same dosage with good results. Sixty-two were malignancies, in which from 4,000 to 7,200 mg.-hrs. of radium plus four hours of external radiation by X-ray was the rule. Only two patients have passed the five-year period, though it is expected that several of the others will. Only fourteen have died.

W. W. WATKINS, M.D.

SINUSES (DIAGNOSIS)

Accessory Sinus Disease in Children. I. R. Vaile. Can. Med. Assn. Jour., February, 1930, XXII, 198.

The symptom group of this condition comprises constant "head colds," profuse nasal discharge, mouth breathing, frequently running ears, and periodical attacks of sore throat.

The X-ray findings are: clouding of both antra in all cases, and polypoid change and thickening of mucous membrane in some. No involvement of the frontal or sphenoid sinuses, and few of ethmoiditis were found in the author's group of cases. No evidence of empyema of the antrum was found.

Antroscopic examination with the Spielberg antroscope showed thickening and congestion of the mucous membrane, and occasionally small and large polypi.

Two types of treatment were followed: palliative and surgical. Palliative treatment was tried in every case, which consisted of daily suction, spraying with 10 per cent argyrol, and exposure to radiant heat. This cured 80 per cent of the cases. If palliative treatment failed, surgical measures were employed. These consisted in puncturing the antrum and irrigation with normal saline, sometimes followed with 2 per cent mercurochrome. This irrigation should be kept up for six weeks or more.

L. J. CARTER, M.D.

Roentgenology of the Accessory Nasal Sinuses. Dorwin L. Palmer. Am. Jour. Surg., March, 1930, VIII, 657.

In this article the author describes the Rhiese technic. This is taken with the sagittal plane of the skull at an angle of 23 degrees and with the head turned in the oblique position on either side, thus throwing the sphenoid and ethmoid labyrinths over the orbit on the side being examined. Both sides should be done stereoscopically. He believes that this technic is the most valuable for the routine study of the sphenoids and ethmoids, and that films made in the Waters position give dependable information regarding the maxillary antra and the frontal cells.

He believes that only when the otolaryngologist and the roentgenologist study the cases together, with careful attention to the surgical findings compared with the roentgen picture, can the greatest benefit be derived.

H. P. DOUB, M.D.